

MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. LII.

JANUARY 8, 1892.

No. 3

E. J. STONE, M.A., F.R.S., Vice-President, in the Chair.

Edward Herbert Lees, Orbost, Victoria, Australia;

J. de Mendizábal Tamborrel, 13 Calle de Jesús, Mexico;

J. S. Slater, Professor of Civil Engineering, Civil Engineering College, Seebpore, Calcutta;

Arthur Thornton, M.A., Christ's College, Cambridge, Giggleswick School, Yorkshire.

W. Livingstone Watson, Ayton, Abernethy, Perthshire,

were balloted for and duly elected Fellows of the Society.

The following candidate was proposed for election as a Fellow of the Society, the name of the proposer, from personal knowledge, being appended:—

Arthur Gibbons, Lecturer in Science, Head Master of the Science, Art, and Technical School, Brierley Hill, Dudley (proposed by J. C. Roger).

Fifty-six presents were announced as having been received since the last meeting, including, amongst others:—

Preparation and discussion of the Draper Catalogue, by E. C. Pickering (*Harvard Observatory Annals*, vol. xxvi. part 1), presented by the Observatory; the collected Mathematical papers of Arthur Cayley, vol. iv., presented by the author.

Note on some Values of the Sun's Mean Horizontal Parallax which have been deduced from the Transit of Venus Observations made in 1882. By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

The recent publication by Professors Harkness and Auwers of the results obtained by them from the Photographic and Heliometer Observations of the Transit of *Venus*, 1882, has suggested to me the desirability of recalling attention to the results obtained, 1887, from a discussion of the contact observations of the Transit of *Venus* which were made in co-operation with the expeditions sent out by the British Government.

If da^s and $d\Delta''$ denote the relative corrections, in right ascension and north polar distance respectively, which are required by Le Verrier's Tables of *Venus* and the Sun for the time of the transit, the values of the mean horizontal equatorial parallax π , which I found from the "Internal Contacts," were expressed under the forms

Ingress Observations :

$$\pi = 8''.823 \pm 0.033 + 0.065 \cdot da^s - 0.0027 \cdot d\Delta''.$$

Egress Observations :

$$\pi = 8''.855 \pm 0.036 - 0.068 \cdot da^s - 0.0099 \cdot d\Delta'',$$

or, combining the results,

$$\pi = 8''.839 \pm 0.024 - 0.0015 \cdot da^s - 0.0063 \cdot d\Delta''.$$

The resulting values of π in these equations are slightly affected by any existing errors da^s and $d\Delta''$.

The Photographic and Heliometer Observations should afford special facilities for the determination of such relative corrections as da^s and $d\Delta''$, and the results obtained by Professors Harkness and Auwers for these quantities are in close agreement.

If we adopt the values found by Professor Auwers, viz. :

$$da^s = \frac{9''.13}{15}, \quad d\Delta'' = -1''.99,$$

the value of π given by the Internal Contacts becomes

$$\pi = 8''.850 \pm 0''.024.$$

The results obtained by Professors Harkness and Auwers are respectively :

$$\pi = 8''.842 \pm 0''.011$$

$$\pi = 8''.883 \pm 0''.022,$$

which agree in a very satisfactory manner with that which I have found from the Internal Contacts, viz. :

$$\pi = 8''.850 \pm 0.022.$$

The results given by the other contacts observed in 1882 agree within the probable errors of their determinations with those obtained from the Internal Contacts.

On the Relation between Diameter of Image, Duration of Exposure, and Brightness of Objects in Photographs of Stars taken at the Royal Observatory, Greenwich. By W. H. M. Christie, M.A., F.R.S., Astronomer Royal.

Since the 13-inch photographic equatoreal was mounted and brought into working order, a number of experimental photographs have been taken at Greenwich with a view to determining the increase of diameter of star disc with exposure, and the relation between the brightness of a star and the exposure required to photograph it. Thanks to the fine definition and excellent clock-work of Sir Howard Grubb's instrument, the star images on these photographs are as a rule remarkably sharp, and very small measurable discs have been obtained in the case of faint stars.

Photographs of selected regions, for which Professor Pritchard has determined with the wedge photometer the magnitudes of certain stars of 9th and 11th magnitude, have been taken with a graduated series of exposures, and the diameters of the star discs on certain of these photographs have been measured under a microscope with a filar micrometer. The microscope has a magnifying power of about 15, referred to a distance of 10 inches. The star discs measured were scattered over the field up to a distance of 60' from the centre, the plates being placed about 1^{mm} within the focus for the centre, *i.e.* focussed on a point about 52' from the centre, so as to equalise the definition over the field.

I.—*The Relation between Diameter of Image and Duration of Exposure.*

Two distinct formulæ have been proposed to express this relation, both of which are, from the nature of the case, empirical:—

1. The diameter varies as a power of the exposure, *i.e.*,

$$\frac{d}{d_0} = \left(\frac{t}{t_0} \right)^p \quad \text{or} \quad \log d - \log d_0 = p (\log t - \log t_0)$$

where d, d_0 are the diameters of the images of the same star corresponding to exposures of t^s and t_0^s respectively under similar

conditions, and p should be a constant; p has been found by Professor Pritchard, M. Charlier, and others to be one-quarter, but Bond found it to be one-half, and Mr. Turner found that it varied from less than one-third for small diameters to more than one-third for large diameters, tending towards the square root for the former and towards the fourth root for the latter.

2. The diameter increases as the logarithm of the exposure, *i.e.*,

$$d - d_0 = m (\log t - \log t_0)$$

where m should be a constant.

It will be shown that either of these formulæ satisfactorily represents the measures of diameters on the Greenwich photographs, the discussion of which leads to the conclusion that the square root of the diameter increases as the logarithm of the exposure, *i.e.*,

$$\sqrt{d} - \sqrt{d_0} = n (\log t - \log t_0),$$

n being very nearly unity when d is expressed in seconds of arc.

The following tables give the results of measures of diameters of star images with various exposures, on six photographs, the exposure being made in the order stated under each photograph. The total number of measures here discussed is about 2220, 830 images of 153 stars having been measured, each at least twice, and usually by two or more measurers. The initials of the Measurers, A. E., A. R., E. R., and W. C., are those of Miss Everett, Miss Russell, Miss Rix, and Mr. Christie. Care was taken to make the measures on the same system throughout, the diameter measured being intermediate between that of the extreme penumbra and of the nucleus, so that it should represent fairly the total photographic action in the case of small faint images as well as of the denser images. In a few cases, where a line of the *réseau* or a defect on the film interfered with the image, it has been necessary, in taking means for groups, to supply a value of diameter by comparison with other measures, without, however, introducing any appreciable uncertainty in the result.

In the several columns of the tables are given:—1. Duration of exposure in seconds; 2, its logarithm; 3, diameter in seconds of arc; 4, its square root; 5, its logarithm; 6, 7, and 8, the resulting values for m , n , and p in the three formulæ given above, formed by dividing the respective differences of consecutive values of d , $\sqrt{d}$ and $\log d$ by the differences of $\log t$. The progression in the values of m and p is evident, and it is clear that the value 0.25 for p will not represent the smaller diameters. The magnitudes given for stars of 9 and 11 magnitudes (marked photom.) are taken from the lists recently issued from the Oxford University Observatory for selected fields, which have proved of the greatest service in the inquiry. The numeration of the stars (1 to 12, 9 mag., 13 to 24, 11 mag.) has also been taken

from these lists. Argelander's magnitudes from the Bonn Durchmusterung are given for the brighter stars.

Photo. 128. λ Serpentis. 1891 July 17.

Exposures: 12^s, 15^s, 20^s, 30^s, 40^s, 250^s, 187½^s, 125^s, 94^s, 75^s.

Photographer: Mr. Criswick.

Measurers: A. E., E. R., W. C. Each star was measured by 3 observers, 5 measures in all being made in most cases.

I. λ Serpentis; 4.5 mag. (Arg.); 4.7 (Uran. Oxon.).

<i>t</i>	log <i>t</i>	<i>d</i>	$\sqrt{d}$	log <i>d</i>	<i>m</i>	<i>n</i>	<i>p</i>
250	2.398	19.70	4.44	1.295	12.1	1.44	.28
187½	2.273	18.19	4.26	1.260	11.6	1.36	.30
125	2.097	16.15	4.02	1.208	5.4	0.73	.14
94	1.973	15.48	3.93	1.190	7.3	0.92	.21
75	1.875	14.76	3.84	1.169	3.6	0.48	.11
40	1.602	13.78	3.71	1.139	7.9	1.04	.26
30	1.477	12.79	3.58	1.107	7.5	1.08	.27
20	1.301	11.47	3.39	1.060	4.2	0.64	.17
15	1.176	10.94	3.31	1.039	4.4	0.72	.18
12	1.079	10.51	3.24	1.022			

II. 5 stars. 8.8 to 9.2 mag.

Mean mag. 9.06 photom. (9.04 Arg.)

250	2.398	6.41	2.53	0.807	5.0	1.04	.36
187½	2.273	5.78	2.40	0.762	2.6	0.51	.20
125	2.097	5.33	2.31	0.727	5.6	1.29	.48
94	1.973	4.63	2.15	0.666	5.4	1.33	.54
75	1.875	4.10	2.02	0.613	3.2	0.84	.39
40	1.602	3.22	1.79	0.508	2.9	0.80	.42
30	1.477	2.86	1.69	0.456	2.7	0.85	.45
20	1.301	2.38	1.54	0.377	2.2	0.72	.41
15	1.176	2.11	1.45	0.324	2.7	0.93	.61
12	1.079	1.85	1.36	0.267			

III. 9 stars. 10.7 to 11.2 mag.

Mean mag. 10.96 photom.

250	2.398	2.96	1.72	0.471	2.9	0.88	.45
187½	2.273	2.60	1.61	0.415	3.4	1.14	.65
125	2.097	2.00	1.41	0.301	1.1	0.32	.24
94	1.973	1.87	1.37	0.272			

Photo. 174. ω^2 Cygni. 1891 October 7.Exposures: 5^s , 10^s , 20^s , 40_1^s , 80_1^s , 640^s , 320^s , 160^s , 80_2^s , 40_2^s .

Photographer: Miss Rix.

Measurers: A. E., W. C., E. R., 2 measures by each; 40_1^s and 40_2^s , 80_1^s and 80_2^s , were measured separately, and as there appeared to be no systematic difference between 40_1^s and 40_2^s , and between 80_1^s and 80_2^s , the means of each pair were taken.

a. ω^2 Cygni. 4.9 mag. (Arg.), 5.0 (Uran. Oxon.).

t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
^s 640	2.806	31.07	5.58	1.493	14.2	1.33	.22
320	2.505	26.80	5.18	1.428	16.2	1.67	.29
160	2.204	21.94	4.68	1.341	11.4	1.23	.24
80	1.903	18.50	4.31	1.268	6.8	0.83	.17
40	1.602	16.46	4.06	1.217	8.6	1.10	.25
20	1.301	13.86	3.73	1.142	5.1	0.74	.17
10	1.000	12.32	3.51	1.091	9.3	1.41	.37
5	0.699	9.53	3.09	0.979			

b. B.D. + 48°, 3154; 5.9 mag. (Arg.)

t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
^s 640	2.806	16.56	4.07	1.219	8.5	1.11	.24
320	2.505	14.00	3.74	1.146	7.2	1.01	.24
160	2.204	11.84	3.44	1.073	5.3	0.80	.27
80	1.903	10.24	3.20	1.010	6.2	1.03	.29
40	1.602	8.38	2.89	0.923	7.9	1.47	.49
20	1.301	5.99	2.45	0.777	7.8	1.80	.73
10	1.000	3.64	1.91	0.561	5.9	1.77	.94
	0.699	1.90	1.38	0.279			

c. B.D. + 48°, 3148; 7.5 mag. (Arg.)

t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
^s 640	2.806	18.33	4.28	1.263	9.2	1.11	.24
320	2.505	15.56	3.95	1.192	8.6	1.16	.26
160	2.204	12.98	3.60	1.113	6.8	0.97	.25
80	1.903	10.94	3.31	1.039	4.5	0.74	.19
40	1.602	9.58	3.09	0.981	7.1	1.21	.37
20	1.301	7.43	2.73	0.871	4.5	0.90	.29
10	1.000	6.07	2.46	0.783	8.4	1.91	.77
5	0.699	3.55	1.89	0.550			

d. B.D. + 48°, 3128; 6.0 mag. (Arg.); 5.64 mag. (Harv. Photom.).

ϵ	$\log \epsilon$	d	$\sqrt{d}$	$\log d$	m	n	p
^s 640	2.806	19.41	4.41	1.288	8.4	1.00	.23
320	2.505	16.87	4.11	1.227	10.0	1.31	.28
160	2.204	13.87	3.72	1.142	8.4	1.16	.29
80	1.903	11.33	3.37	1.054	4.3	0.67	.18
40	1.602	10.03	3.17	1.001	5.8	0.96	.27
20	1.301	8.30	2.88	0.919	4.0	0.73	.23
10	1.000	7.10	2.66	0.851	7.1	1.43	.51
5	0.699	4.99	2.23	0.698			

e. B.D. + 49°, 3310; 6.7 mag. (Arg.)

ϵ	$\log \epsilon$	d	$\sqrt{d}$	$\log d$	m	n	p
^s 640	2.806	13.78	3.71	1.139	5.4	0.73	.18
320	2.505	12.16	3.49	1.085	7.1	1.07	.28
160	2.204	10.03	3.17	1.001	6.8	1.13	.33
80	1.903	7.98	2.83	0.902	2.1	0.40	.12
40	1.602	7.35	2.71	0.866	5.6	1.11	.37
20	1.301	5.68	2.38	0.754	2.8	0.60	.23
10	1.000	4.83	2.20	0.684	3.9	0.93	.40
5	0.699	3.67	1.92	0.564			

g. B.D. + 49°, 3298; 6.9 mag. (Arg.)

ϵ	$\log \epsilon$	d	$\sqrt{d}$	$\log d$	m	n	p
^s 640	2.806	12.71	3.57	1.104	4.0	0.60	0.33
320	2.505	11.51	3.39	1.004	7.9	1.23	0.14
160	2.204	9.14	3.02	0.961	5.6	0.97	0.30
80	1.903	7.45	2.73	0.872	3.8	0.73	0.24
40	1.602	6.30	2.51	0.799	6.0	1.29	0.48
20	1.301	4.51	2.12	0.654	2.6	0.64	0.28
10	1.000	3.73	1.93	0.571	5.4	1.60	0.82
5	0.699	2.10	1.45	0.323			

z. B.D. + 48°, 3145; 9.0 mag. (Arg.); 9.02 mag. (photom.)

ϵ	$\log \epsilon$	d	$\sqrt{d}$	$\log d$	m	n	p
^s 640	2.806	9.51	3.08	0.978	7.2	1.23	0.38
320	2.505	7.33	2.71	0.865	4.9	0.98	0.33
160	2.204	5.86	2.42	0.768	8.1	1.87	0.77
80	1.903	3.45	1.86	0.538	2.6	0.74	0.37
40	1.602	2.68	1.64	0.428			

Photo. 178. 36 Pegasi. 1891 October 9.

Exposures: 5^s , 10^s , 20^s , 40_1^s , 80_1^s , 640^s , 320^s , 160^s , 80_2^s , 40_2^s , 10_2^s .

Photographer: Mr. Criswick.

Measurers: A. E., A. R.

40_1^s and 40_2^s , 80_1^s and 80_2^s , were measured separately and the means of each pair taken.

I. 5 stars. Nos. 1-5. 8.6 to 9.0 mag. photom.

Mean mag. 8.90 photom. (9.08 Arg.)

t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
640^s	2.806	8.02	2.83	0.905	6.3	1.16	.39
320	2.505	6.14	2.48	0.789	3.6	0.77	.28
160	2.204	5.06	2.25	0.705	6.0	1.50	.64
80	1.903	3.25	1.80	0.513	3.7	1.13	.62
40	1.602	2.12	1.46	0.328	2.4	0.93	.60
20	1.301	1.40	1.18	0.148			

II. 4 stars. Nos. 8, 9, 11, 12. 9.2 to 9.4 mag. photom.

Mean mag. 9.28 photom. (9.25 Arg.)

t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
160^s	2.204	3.43	1.85	0.536	4.1	1.20	.64
80	1.903	2.21	1.49	0.345	2.8	1.06	.68
40	1.602	1.38	1.17	0.141			

III. 7 stars. Nos. 13-19. 10.8 to 11.0 mag. photom.

Mean mag. 10.87 photom.

t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
640^s	2.806	3.74	1.93	0.574	4.4	1.26	.64
320	2.505	2.41	1.55	0.383	3.8	1.43	.94
160	2.204	1.26	1.12	0.101			

IV. 5 stars. Nos. 20-24. 11.0 to 11.3 mag. photom.

Mean mag. 11.16 photom.

t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
640^s	2.806	2.47	1.57	0.394	4.0	1.46	.95
320	2.505	1.28	1.13	0.109			

Photo. 180. 36 Pegasi. 1891 October 12.

Exposures: 63_1^s , 398^s , 251^s , 159^s , 100^s , 63_2^s , 10^s , 16^s , 25^s , 40^s , 63_3^s .

Photographer: Miss Everett.

Measurers: E. R., A. E.

63_2^s and 63_3^s were measured for Group I. and the means taken.

I. 3 stars. 36 *Pegasi*, B.D. + 8° 5880, B.D. + 8° 5870.

Mags. 5·8, 7·7, 7·8 Arg.

t s	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
398	2·600	12·90	3·59	1·111	5·7	0·80	·20
251	2·400	11·76	3·43	1·071	7·2	1·10	·29
159	2·201	10·32	3·21	1·014	5·7	0·90	·26
100	2·000	9·18	3·03	0·963	5·7	0·95	·29
63	1·799	8·04	2·84	0·905	4·8	0·90	·28
40	1·602	7·08	2·66	0·850	3·9	0·75	·26
25	1·398	6·30	2·51	0·799	5·1	1·05	·38
16	1·204	5·28	2·30	0·723	7·2	1·70	·70
10	1·000	3·84	1·96	0·584			

II. 3 stars. Nos. 1, 5, 6. 8·6 to 9·1 mag.

Mean mag. 8·90 photom. (9·03 Arg.)

s		d	$\sqrt{d}$				
398	2·600	6·54	2·56	0·816	4·5	0·95	·33
251	2·400	5·64	2·37	0·751	5·4	1·15	·46
159	2·201	4·56	2·14	0·659	3·6	0·90	·38
100	2·000	3·84	1·96	0·584	2·4	0·60	·29
63 ₂	1·799	3·36	1·84	0·526	3·0	0·90	·43
40	1·602	2·76	1·66	0·441	3·3	1·05	·60
25	1·398	2·10	1·45	0·322	2·7	1·00	·65
16	1·204	1·56	1·25	0·193			

III. 6 stars. Nos. 1-6. 8·6 to 9·1 mag.

Mean mag. 8·93 photom. (9·12 Arg.)

s		d	$\sqrt{d}$				
63 ₂	1·799	3·48	1·87	0·542	3·6	1·05	·51
40	1·602	2·76	1·66	0·441	2·1	0·65	·36
25	1·398	2·34	1·53	0·369	3·6	1·30	·79
16	1·204	1·62	1·27	0·210			

IV. 6 stars. Nos. 7-12. 9·1 to 9·4 mag.

Mean mag. 9·25 photom. (9·20 Arg.)

s		d	$\sqrt{d}$				
63 ₂	1·799	2·46	1·57	0·391	2·1	0·70	·41
40	1·602	2·04	1·43	0·310	2·4	0·90	·59
25	1·398	1·56	1·25	0·193			

V. 8 stars. Nos. 13-20. 10·8 to 11·0 mag.

Mean mag. 10·89 photom.

s		d	$\sqrt{d}$				
398	2·600	3·00	1·73	0·477	3·0	0·90	0·49
251	2·400	2·40	1·55	0·380	1·8	0·60	0·35
159	2·201	2·04	1·43	0·310	2·4	0·90	0·59
100	2·000	1·56	1·25	0·193			

VI. 4 stars. Nos. 21-24. 11.1 to 11.3 mag.

Mean mag. 11.20 photom.

t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
^s		"	"				
398	2.600	2.40	1.55	0.380	4.8	1.75	1.11
251	2.400	1.44	1.20	0.158	1.2	0.50	0.40
159	2.201	1.20	1.10	0.079			

Photo. 181. 36 Pegasi. 1891 October 12.

Exposures: 100₁^s, 631^s, 398^s, 100₂^s, 16^s, 25^s, 40^s, 40^s, 63^s, 100₃^s.

Photographer: Miss Everett.

Measurers: A. E., A. R.

It was intended also to have exposures of 251^s and 159^s, but, as there is only one image corresponding, it has been thought better not to use the measures of this image, there being no means of determining which exposure it represents. There seems to be no doubt as to the long exposures of 631^s and 398^s, the clock times of beginning and ending having been recorded. The exposure 100₂^s is checked by the measures for 100₃^s. The sky was not quite free from cloud.

I. 3 stars. 36 Pegasi, B.D. + 8°.5880, B.D. + 8°.5870. Mags. 5.8, 7.7, 7.8 Arg.

t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
^s		"	"				
631	2.800	14.72	3.84	1.168	5.9	0.80	0.18
398	2.600	13.54	3.68	1.132	4.7	0.67	0.17
100 ₂	2.000	10.76	3.28	1.032			
100 ₃	2.000	10.68	3.27	1.029	10.6	1.75	0.48
63	1.799	8.60	2.93	0.935	6.3	1.10	0.35
40	1.602	7.35	2.71	0.866	6.5	1.25	0.42
25	1.398	6.06	2.46	0.783	6.4	1.35	0.52
16	1.204	4.78	2.19	0.679			

II. 3 stars, Nos. 1, 5, 6. 8.6 to 9.1 mag.

Mean mag. 8.90 photom. (9.03 Arg.)

t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
^s		"	"				
631	2.800	7.36	2.71	0.867	4.5	0.85	0.29
398	2.600	6.46	2.54	0.810	3.5	0.73	0.28
100 ₂	2.000	4.32	2.08	0.636			
100 ₃	2.000	4.46	2.11	0.649	6.7	1.75	0.79
63	1.799	3.06	1.75	0.486	2.1	0.65	0.32
40	1.602	2.64	1.62	0.422	3.2	1.05	0.61
25	1.398	2.00	1.41	0.301	3.1	1.20	0.81
16	1.204	1.38	1.17	0.140			

III. 6 stars, Nos. 1-6. 8.6 to 9.1 mag.

Mean mag. 8.93 photom. (9.12 Arg.)

<i>t</i> ^s	log <i>t</i>	<i>d</i>	$\sqrt{d}$	log <i>d</i>	<i>m</i>	<i>n</i>	<i>p</i>
100 ₂	2.000	4.76	2.18	0.678			
100 ₃	2.000	4.68	2.16	0.670	7.0	1.75	0.77
63	1.799	3.32	1.82	0.521	3.0	0.85	0.43
40	1.602	2.72	1.65	0.435	3.5	1.15	0.65
25	1.398	2.02	1.42	0.305	3.1	1.20	0.79
16	1.204	1.40	1.18	0.146			

IV. 6 stars, Nos. 7-12. 9.1 to 9.4 mag.

Mean mag. 9.25 photom. (9.20 Arg.)

<i>s</i>							
100 ₂	2.000	3.83	1.96	0.583			
100 ₃	2.000	3.55	1.89	0.551	6.3	1.85	0.90
63	1.799	2.44	1.56	0.387	3.6	1.25	0.76
40	1.602	1.72	1.31	0.236	1.4	0.55	0.39
25	1.398	1.44	1.20	0.158			

V. 8 stars, Nos. 13-20. 10.8 to 11.0 mag.

Mean mag. 10.89 photom.

<i>s</i>							
631	2.800	3.98	1.99	0.601	5.3	1.40	.68
398	2.600	2.92	1.71	0.465	1.8	0.57	.33
100 ₂	2.000	1.71	1.33	0.232			
100 ₃	2.000	1.97	1.40	0.295	2.6	1.10	.72
63	1.799	1.32	1.15	0.121			

VI. 4 stars, Nos. 21-24. 11.1 to 11.3 mag.

Mean mag. 11.20 photom.

<i>s</i>							
631	2.800	3.01	1.73	0.477	3.3	1.00	.53
398	2.600	2.35	1.53	0.371	1.4	0.50	.33
100 ₂	2.000	1.55	1.24	0.190			
100 ₃	2.000	1.49	1.22	0.173			

*Photo. 185. ω^2 Cygni. 1891 October 14.*Exposures : 41^m 52^s, 251^s, 40^s, 25^s, 159^s, 100^s, 16^s.

Photographer : Miss Everett.

Measurers : A. E., A. R. Ten measures of ω^2 Cygni by A. E. and A. R. and 2 measures of each of the other stars by A. E. or A. R. (alternately).

I. ω^2 Cygni. 4.9 mag. (Arg.) 5.0 (Uran. Oxon.).

$\begin{smallmatrix} m \\ s \end{smallmatrix}$	t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
41	52	3.400	45.62	6.75	1.659	18.10	1.50	0.22
	251	2.400	27.52	5.25	1.440	14.7	1.47	.25
	159	2.201	24.60	4.96	1.391	11.0	1.69	.30
	100	2.000	21.38	4.62	1.330	11.0	1.26	.25
	40	1.602	17.00	4.12	1.230	8.6	1.08	.23
	25	1.398	15.24	3.90	1.183	6.9	0.88	.21
	16	1.204	13.90	3.73	1.143			

II. 8 stars. 5.9 to 7.9 mag. Arg.

Mean mag. 7.08 Arg.

$\begin{smallmatrix} m \\ s \end{smallmatrix}$	t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
41	52	3.400	25.49	5.05	1.406	11.1	1.25	.25
	251	2.400	14.42	3.80	1.159	8.9	1.12	.29
	159	2.201	12.65	3.56	1.102	7.6	1.15	.28
	100	2.000	11.12	3.33	1.046	5.2	0.80	.22
	40	1.602	9.07	3.01	0.958	5.8	1.00	.30
	25	1.398	7.88	2.81	0.897	6.3	1.19	.38
	16	1.204	6.66	2.58	0.824			

III. 6 stars. 6.8 to 8.0 mag. Arg.

Mean mag. 7.35 Arg.

$\begin{smallmatrix} m \\ s \end{smallmatrix}$	t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
41	52	3.400	17.08	4.13	1.232	7.9	1.11	.27
	251	2.400	9.14	3.02	0.961	6.0	1.01	.31
	159	2.201	7.94	2.82	0.900	5.7	1.05	.33
	100	2.000	6.80	2.61	0.833	4.0	0.83	.29
	40	1.602	5.20	2.28	0.716	5.5	1.28	.52
	25	1.398	4.08	2.02	0.611	3.8	0.98	.45
	16	1.204	3.34	1.83	0.524			

IV. 3 stars. 8.64 to 9.02 mag. photom.

Mean mag. 8.86 photom. (9.07 Arg.)

$\begin{smallmatrix} m \\ s \end{smallmatrix}$	t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
41	52	3.400	16.18	4.02	1.209	7.7	1.11	.28
	251	2.400	8.44	2.91	0.926	4.8	0.91	.26
	159	2.201	7.48	2.73	0.874	6.6	1.25	.42
	100	2.000	6.16	2.48	0.790	4.6	1.00	.39
	40	1.602	4.32	2.08	0.636	2.4	0.59	.26
	25	1.398	3.84	1.96	0.584	4.4	1.19	.57
	16	1.204	2.98	1.73	0.474			

V. 9 stars. 8.99 to 9.39 mag. photom.

Mean mag. 9.17 photom. (9.32 Arg)

t	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
$\begin{smallmatrix} m \\ 41 \end{smallmatrix} \begin{smallmatrix} s \\ 52 \end{smallmatrix}$	3.400	11.94	3.46	1.077	6.4	1.10	.33
251	2.400	5.56	2.36	0.745	6.2	1.40	.54
159	2.201	4.33	2.08	0.637	4.6	1.15	.52
100	2.000	3.41	1.85	0.532	2.4	0.71	.35
40	1.602	2.47	1.57	0.393	3.1	1.03	.63
25	1.398	1.84	1.36	0.265	3.0	1.24	.85
16	1.204	1.26	1.12	0.100			

VI. 12 stars. 10.7 to 11.2 mag. photom.

Mean mag. 10.93 photom.

m	s	$\log t$	d	$\sqrt{d}$	$\log d$	m	n	p
41	52	3.400	6.24	2.50	0.795	3.6	0.89	.38
251		2.400	2.58	1.61	0.412	3.0	1.01	.57
159		2.201	1.99	1.41	0.299	1.8	.65	.43
100		2.000	1.63	1.28	0.212			

The values of p and n have been grouped, taking $\log$. diameter as argument, and the means of the groups, with the number of values in each group, are exhibited in the following table, which shows clearly the progression in the values for p , while n is sensibly constant. The values corresponding to the 5^s exposure in Photo. 174 have not been used in forming these means, as there might be a sensible error in estimating the duration of such a short exposure. For simplicity of computation the values of p and n have been treated as of equal weight in forming the means.

MEANS OF GROUPS.

Log. Diam. Limits.	Mean.	No. in Group.	Diam.	$\sqrt{\text{Diam.}}$	p	n	Discordance from Mean.
0.12-0.30	0.24	19	1.74	1.32	.657	0.996	-.039
0.31-0.41	0.36	12	2.29	1.51	.530	0.910	-.125
0.42-0.53	0.46	16	2.88	1.70	.526	1.039	+.004
0.56-0.66	0.61	15	4.07	2.02	.508	1.185	+.150
0.67-0.78	0.72	12	5.25	2.29	.403	1.060	+.025
0.78-0.88	0.83	14	6.76	2.60	.351	1.047	+.012
0.88-0.98	0.92	15	8.32	2.88	.301	1.017	-.018
0.98-1.08	1.03	16	10.72	3.27	.242	0.924	-.111
1.08-1.18	1.13	15	13.49	3.67	.220	0.922	-.113
1.18-1.55	1.30	17	19.95	4.47	.240	1.246	+.211
Total ...	151				Mean ...	1.0346	±.085

The discordances from the mean in the separate values of n (given in the last column) appear to be accidental, and we may conclude that the formula—

$$\sqrt{d} - \sqrt{d_0} = 1.03 (\log t - \log t_0),$$

or

$$\sqrt{\text{diam.}} = 1.03 \times \log \text{exposure} + \text{const.}$$

(the diameter being expressed in seconds of arc) represents the measures satisfactorily, through the range $1''.3$ to $35''.5$ in the diameters, corresponding to a range of 8 magnitudes, or to a ratio of 1 to 1600 in the limiting light-intensities.

The following are the probable errors of a determination of n in the tables, inferred from the discordances from the mean in the several groups:

I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	Mean
.259	.196	.191	.337	.264	.143	.156	.177	.158	.186	.207

Each of these values represents the probable error of a determination of the quantity $\frac{\sqrt{d} - \sqrt{d'}}{\log t - \log t'}$. The mean value of $\log t - \log t' = 0.226$, whence the probable error of a determination of $\sqrt{d} - \sqrt{d'}$ is 0.047, corresponding to 0.117 magnitude, since 0.4 in $\log t - \log t'$ or in $\sqrt{d} - \sqrt{d'}$ represents 1 magnitude. The probable error of a result for $\sqrt{d}$ in the above tables is therefore $\frac{0.047}{\sqrt{2}} = 0.033$, corresponding to 0.083 magnitude.

Each of these results for $\sqrt{d}$ is the mean of about eleven measures, either of one star or of a small group, all taken with the same exposure, there being 2220 measures for 197 values of $\sqrt{d}$. In this probable error is included the systematic error depending on the state of the sky and other causes incidental to the particular exposure, this systematic error being probably an important element in the probable error inferred from the discordances in the values of n .

The probable error for a determination of n in the tables appears to be approximately the same for each of the ten groups, though it tends to become slightly smaller for the groups with larger diameter and longer exposure.

As the value of n for each group is the mean of about fifteen separate values (on the average), its probable error (considering all the groups as of approximately the same weight) would be 0.053, and the mean error 0.063; whereas the mean discordance from the formula is 0.085, a quantity which so slightly exceeds the computed mean error, that the formula may safely be taken as representing the observations within the limits of accidental error.

The accompanying curves exhibit the results graphically.

Fig. 1 shows the value of p as ordinate, with log. diameter as abscissa, the curve being drawn freely by hand among the dots.

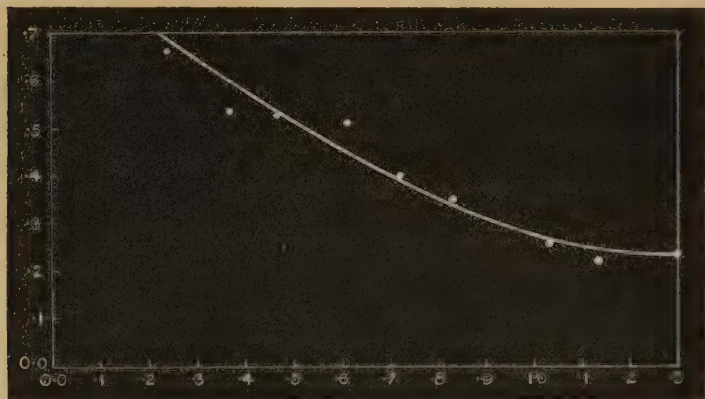
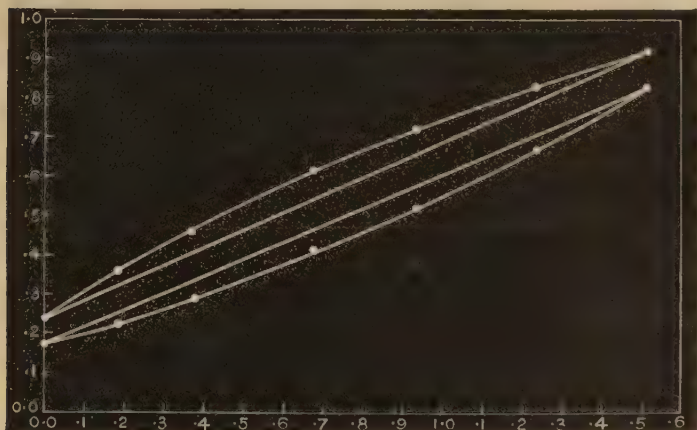


Fig. 2.—The upper curve represents the log. diameter (as ordinate), and the lower the diameter (as ordinate), with the log. duration of exposure (diminished by a constant) as abscissa, the abscissa being deduced from the log. diameter by summation, taking the value of p from the curve in fig. 1. The straight lines represent the formulæ

$$\log d - \log d_0 = p (\log t - \log t_0),$$

and

$$d - d_0 = m (\log t - \log t_0),$$



where m and p are constants deduced from the extreme values. The latter represents the measures a little better than the former, the truth lying between the two.

Fig. 3 represents the square root of the diameter as ordinate with the log. duration of exposure (diminished by a constant) as abscissa, deduced as for fig. 2. It will be seen that the dots thus deduced lie sensibly on a straight line.

$$\sqrt{d} - \sqrt{d_0} = 1.03 (\log t - \log t_0).$$

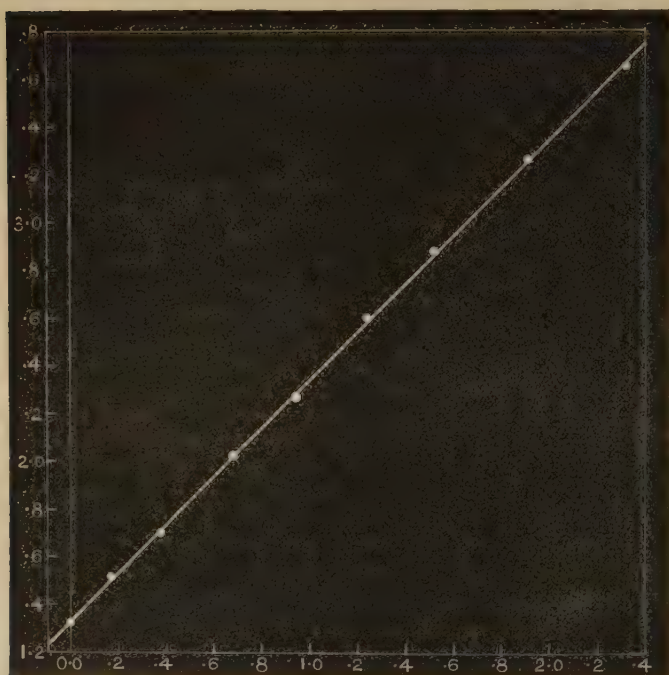
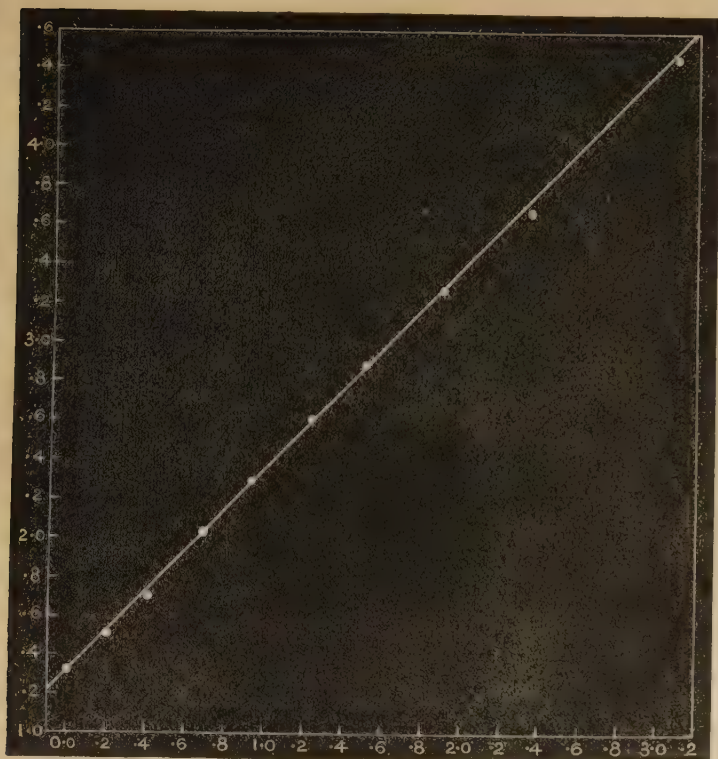


Fig. 4.—The dots exhibit the relation between $\sqrt{\text{diameter}}$ as ordinate and $\log.$ duration of exposure (diminished by a constant) as abscissa, the latter being obtained directly from the values for n in the table (Means of Groups). The straight line represents the formula

$$\sqrt{d} - \sqrt{d_0} = 1.03 (\log t - \log t_0).$$



The following table gives the values of $y = \sqrt{\text{diam.}}$ and of $x = \log t - \log t_0$, from which the dots have been plotted, the values of x being obtained by summation of the quantities $\delta x = \frac{\delta y}{n}$, where n is the mean of the preceding and following observed values applicable to the interval δy . The third column shows the values of $x = \frac{y - y_0}{1.03}$ from the formula, and the fourth the discordance, calculated—observed, in $\log t$, converted into discordance in magnitude in the last column, by dividing by 0.4.

$\sqrt{\text{diam.}}$ y	$\log t - \log t_0$ x	$\frac{y - y_0}{1.03}$	Discordance C-O.	
"	"	"	in $\log t$	in mag.
1.32	0.000	0.000		
1.51	0.199	0.184	— .015	— .038
1.70	0.394	0.369	— .025	— .062
2.02	0.682	0.680	— .002	— .005
2.29	0.922	0.942	+ .020	+ .050
2.60	1.216	1.243	+ .027	+ .068
2.88	1.487	1.515	+ .028	+ .070
3.27	1.889	1.893	+ .004	+ .010
3.67	2.322	2.282	— .040	— .100
4.47	3.060	3.058	— .002	— .005
Mean Discordance			$\pm .018$	$\pm .045$

Thus the mean discordance between the abscissæ deduced directly from the observations, and those given by the formula, corresponds to less than one-twentieth of a magnitude through a range of eight magnitudes.

II.—*The Relation between Duration of Exposure and Brightness of Star photographed.*

A discussion of the measures of diameters given in the preceding tables compared with the valuable photometric determinations of magnitudes of the 9th and 11th magnitude stars, made at the Oxford University Observatory with Professor Pritchard's wedge photometer, and with Argelander's magnitudes for stars of about the 7th and 9th magnitudes, gives data for determining whether the law that, for equal photographic effects,

$$\text{Duration of exposure} \times \text{brightness of object} = \text{const.}$$

holds satisfactorily under the conditions and within the limits here considered.

It will be remembered that at the meeting of the Comité de la Carte du Ciel at Paris, in 1889, it was decided that, in order to photograph the 11th magnitude stars, the exposure should be that required for Argelander's 9th magnitude, multiplied by 6.25 (or, rather, 6.31, as it should have been), the intention being to prolong Argelander's scale from mag. 9.0 to mag. 11.0. Since then doubts have been raised as to the validity of this procedure, it being considered that the exposure must be increased in a much higher ratio than 1 to 6.31 to photograph stars fainter by 2.0 magnitudes. The present discussion is directed principally to this point, the photographic images of stars of the 9th and 11th magnitudes being compared with the Oxford photometric magnitudes. As a further check, the photographic images of stars of about the 7th and 9th magnitudes have been compared with Argelander's visual magnitudes, but difficulty has been experienced in obtaining a sufficiency of such stars to eliminate the large accidental errors arising from differences between visual and photographic brightness.

In the following comparison of diameters, the first column indicates the two results compared, denoted by the exposure, and the group in the preceding tables; thus 12_2^s denotes the 12^s exposure in Group II., and similarly in other cases. In the second column the difference of $\sqrt{\text{diameter}}$ for the two exposures compared is given, the values being taken from those for the groups in the above-mentioned tables. The third column gives the log. factor by which the exposure should be multiplied to equalise the two photographic images. Since $\delta(\sqrt{\text{diam.}}) = \delta(\log t)$ very nearly, the log. factor is obtained simply by adding to the difference of the logarithms of exposures the quantities in the second column. The log. factor for 1.0 magnitude is obtained at once by dividing by the difference of magnitudes of the groups compared (nearly 2.0 magnitudes in all cases), and the resulting factor for 1 magnitude is given in the last column, this being the factor by which the duration of exposure should be multiplied to obtain equal photographic effect from a star fainter by 1 magnitude.

Comparison of Diameters of 9th and 11th mag. Stars (Oxford Photometric Magnitudes).

Photo. 128.

s	s	$\delta(\sqrt{d})$	Log. factor for 1.0 mag.	Log. factor for 1 mag.	Factor for 1 mag.
$12_2 - 94_3$		-.01	0.88	0.463	2.90
$15_2 - 125_3$		+.04	0.96	0.505	3.20
$20_2 - 187_3$		-.07	0.90	0.474	2.98
$30_2 - 250_3$		-.03	0.89	0.468	2.94
					Mean 3.00
					M 2

Photo. 178.

s s	$\delta(\sqrt{d})$	Log. factor for 1.93 mag.	Log. factor for 1 mag.	Factor for 1 mag.
20 ₁ - 160 ₃	+ .06	0.96	0.497	3.14
40 ₂ - 320 ₄	+ .04	0.94	0.487	3.07
40 ₁ - 320 ₃	- .09	0.81	0.420	2.63
80 ₂ - 640 ₄	- .08	0.82	0.425	2.66
80 ₁ - 640 ₃	- .13	0.77	0.399	2.51
				Mean 2.80

Photo. 180.

s s		for 1.96 mag.		
16 ₃ - 100 ₅	+ .02	0.82	0.418	2.62
25 ₄ - 159 ₆	+ .15	0.95	0.485	3.05
25 ₃ - 159 ₅	+ .10	0.90	0.459	2.88
40 ₄ - 251 ₆	+ .23	0.03	0.525	3.35
40 ₃ - 251 ₅	+ .11	0.91	0.464	2.72
63 ₄ - 398 ₆	+ .02	0.82	0.418	2.62
63 ₃ - 398 ₅	+ .14	0.94	0.480	3.02
				Mean 2.89

Photo. 181.

s s		for 1.96 mag.		
16 ₃ - 63 ₅	+ .03	0.63	0.321	2.09
25 ₄ - 100 ₆	- .03	0.57	0.291	1.95
25 ₃ - 100 ₅	+ .05	0.65	0.332	2.15
40 ₄ - 100 ₆	+ .08	0.48	0.245	1.76
40 ₄ - 398 ₆	- .28	0.72	0.367	2.33
				Mean 2.06

s s				
40 ₃ - 100 ₅	+ .28	0.68	0.347	2.22
40 ₃ - 398 ₅	- .06	0.94	0.480	3.02
63 ₄ - 398 ₆	+ .03	0.83	0.423	2.65
63 ₃ - 398 ₅	+ .11	0.51	0.464	2.91
100 ₄ - 631 ₆	+ .20	1.00	0.510	3.24
100 ₃ - 631 ₅	+ .18	0.98	0.500	3.16
				Mean 2.87

Photo. 185.

s s		for 1.96 mag.		
16 ₅ - 100 ₆	- .16	0.64	0.327	2.12
25 ₅ - 159 ₆	- .05	0.75	0.383	2.42
40 ₅ - 251 ₆	- .04	0.76	0.388	2.44
s m s				
251 ₅ - 4152 ₆	- 14	0.86	0.439	2.75
				Mean 2.43

*Comparison of Diameters of 7th and 9th mag. Stars (Argelander's Magnitudes).**Photo. 185.*

Groups II. and IV. consist of Stars photographically bright as compared with their visual magnitudes.

s	s	$\delta(\sqrt{d})$	Log. factor for 1.78 mag.	Log. factor for 1 mag.	Factor for 1 mag.
16 ₂ —100 ₄		+ .10	0.90	0.506	3.21
25 ₂ —159 ₄		+ .08	0.88	0.494	3.12
40 ₂ —251 ₄		+ .10	0.90	0.506	3.21
	m s				
251 ₂ —41.52 ₁		— .22	0.78	0.438	2.74
					Mean 3.07
			for 1.97 mag.		
16 ₃ —100 ₅		— .02	0.78	0.396	2.49
25 ₃ —159 ₅		— .06	0.74	0.376	2.38
40 ₃ —251 ₅		— .08	0.72	0.365	2.32
	m s				
251 ₃ —41.52 ₃		— .44	0.56	0.284	1.92
					Mean 2.28

Taking the means for each photograph (181 being divided into two groups of diameters under and over 2".1 respectively) we have

Photo.	Factor for 1 magnitude. Oxford photom.	Argelander	Diff. of Mag. for Factor 2.512 Oxford photom. mag.	Argelander mag.
128	3.00	...	0.839	...
178	2.80	...	0.895	...
180	2.89	...	0.868	...
181 ₁	2.06	...	1.274	...
181 ₂	2.87	...	0.873	...
185	2.43	3.07	1.036	0.821
185		2.28		1.117
Means	2.675	2.675	0.964	0.969

It appears that whether we take the Oxford photometric magnitudes or Argelander's, the factor 2.512 for the exposure gives 1.0 magnitude within the limits of accidental error.

Considering the large differences between photographic and visual brightness in the case of individual stars (amounting probably in some instances to nearly ± 1 magnitude) and the accidental variations in atmospheric or instrumental tremors, in the state of the sky, in incipient dew on the object glass, and in sensibility or development of different parts of the photographic film, the discordances in the individual results for the factor are not surprising, and the mean value agrees quite as closely with the law

$$\text{Exposure} \times \text{brightness} = \text{const.}$$

as could be expected.

It is curious, however, that Photo. 181 gives a markedly large factor for the smaller diameters, indicating that the first faint images of 11th magnitude stars were more readily obtained relatively to those of the 9th magnitude stars than the denser images, and Photo. 185 to a certain extent gives a similar result. Both these photographs, which, it may be remarked, were taken in moonlight, show small sharp images even of the faintest stars.

Similar conclusions result from an examination of the images visible on the photographs, made by myself with an achromatic magnifying lens of about 1-inch focus, and tabulated before the plates were measured. In the following table the images visible on Photos. 178, 180, and 181 are indicated by the corresponding exposure, in italics when the image was only faintly visible, in ordinary type when it was fairly distinct, and in heavy type when it was unmistakeable, at a glance, and accurately measurable for diameter. The images with longer exposures were, of course, also visible, but there is no occasion to note them.

Exposures giving Images of 9th and 11th mag. Stars on Photographs of the District round 36 Pegasi.

Star's No.	Magnitude Photom. Arg.		Photo. 178.		Photo. 180.			Photo. 181.		
			S	S	S	S	S	S	S	S
1	8.6	8.7	...	20	...	10	16	...	...	16
2	8.9	9.2	20	40	...	10	16	...	...	16
3	9.0	9.3	20	40	...	10	16	...	...	16
4	9.0	9.1	...	20	...	10	16	...	...	16
5	9.0	9.1	...	20	...	10	16	...	...	16
6	9.1	9.3	20	40	...	...	16	...	...	16
7	9.1	9.0	...	40	...	16	25	...	16	25
8	9.2	9.1	40	80	...	16	25	16	25	40
9	9.2	9.4	80	...	...	25	40	...	16	25
10	9.3	9.2	80	...	...	16	25	...	...	40
11	9.3	9.2	...	40	16	25	40	...	...	16
12	9.4	9.3	40	80	...	40	63	...	25	40
13	10.8	...	80	160	...	63	100	40	63	100
14	10.8	...	...	160	...	63	100	...	40	63
15	10.8	...	160	320	...	63	100	40	63	100
16	10.9	...	80	160	...	63	100	...	63	100
17	10.9	...	...	320	...	63	100	40	63	100
18	10.9	...	160	320	...	63	100	...	63	100
19	11.0	...	80	160	...	63	100	40	63	100
20	11.0	...	160	320	...	63	100	...	63	100
21	11.1	...	160	320	...	100	159	...	...	100
22	11.2	...	...	320	...	100	159	...	63	100
23	11.2	...	...	320	...	100	159	...	63	100
24	11.3	...	160	320	...	159	251	...	100	159

It thus appears that this independent examination fully confirms the results deduced from the measures, particularly in the case of Photo. 181. It is remarkable that on this photograph (taken in moonlight) some 11th magnitude stars were impressed faintly in 40^s, and nearly all in 63^s. Measurable images of all stars down to 11.0 magnitude were obtained in 100^s, both on this photograph and on No. 180. On the other hand, about three times the exposure was required on Photo. 178, a fact which may be explained by a slight dimming of the object glass by dew, noticed by the observer a little time after this photograph was taken.

The results of this discussion may be thus summarised :—

Putting d =diameter (in seconds of arc) of the image of a star of magnitude m (Pogson's scale) with the exposure t (in seconds of time), we have—

I. For the same star with different exposures,

$$\sqrt{d} = 1.03 \log t + \text{const.} \quad (1)$$

an empirical formula which represents the observations through a range of eight magnitudes with a mean apparent error of only ± 0.018 corresponding to ± 0.45 mag.

II. For equal diameters

$$\text{Exposure} \times \text{brightness} = \text{const.}$$

or

$$0.4 \times m = \log t + \text{const.} \quad (2)$$

The relation actually found is

$$0.4 \times m = 0.97 \log t + \text{const.},$$

which is sensibly the same as (2).

III. From (1) and (2) it follows that, for the same exposure, the relation between diameter of image and magnitude of star is

$$0.4 \times m = \text{const.} - \frac{\sqrt{d}}{1.03}$$

or

$$m = \text{const.} - 2.43 \sqrt{d} \quad (3)$$

that is,

$$\text{Magnitude of star} = \text{const.} - 2.43 \times \sqrt{\text{diameter.}}$$

The constants are, of course, different in the different cases. In (1) the constant would be different for stars of different magnitudes; in (2) for stars of different diameter; and in (3) for stars with different exposures. They would also, of course, be slightly different for different plates.

Combining (1), (2), and (3) in one formula, we have

$$m = 2.5 (\log t - 0.97 \sqrt{d}) + \text{const.} \quad (4)$$

which may be considered as replacing the approximate empirical formula given in the "Monthly Notices" for March, 1891, vol. li. p. 284.

Royal Observatory, Greenwich:
1892 January 8.

On the Observations for Coincidence of the Collimators through the Cube of the Transit Circle at the Royal Observatory, Greenwich (11). By H. H. Turner, M.A., B.Sc.

In a former paper (*M.N.* vol. xlv. p. 329) I referred to the fact that when observations for coincidence of the collimators at the Royal Observatory were made by viewing the South Collimator with the North through eight holes of sector form cut in the central cube of the transit circle, the readings were found to differ systematically from those obtained when the view was unobstructed; and I detailed a series of simple experiments which seemed to show that this phenomenon was purely optical. This conclusion has been confirmed by an interesting and elaborate series of experiments by Dr. Wislicenus at Strasburg. (*Ast. Nach.* No. 3067). He states his chief conclusions as follows:—

1. The systematic differences found at Greenwich are purely of an optical nature, and can be obviated by making the hole in cube circular and larger than the object-glasses of the collimators.
2. If the object-glass of a telescope be obscured by concentric discs or rings quite symmetrically, or by symmetrical screens of other forms, such as the radial bars at Greenwich, not only is the character of the focal image altered, but it *may* be displaced laterally.

With regard to the excellent though somewhat obvious suggestion in (1), it may be remarked that there are practical difficulties in the way of adopting it in the case of the Greenwich transit circle; but the point should not be lost sight of in designing a new instrument.

With regard to conclusion (2), Dr. Wislicenus lays some stress on the word *may*. He is inclined to attribute such lateral displacements to residual chromatic and spherical aberrations, which make the actual focus of an object-glass somewhat indefinite. Instead of a bright point we get in fact a short line of light along the optical axis, the brightest point of which is selected for focussing. Cutting off some of the rays, however symmetrically, will cause a different point of this line to be selected, and for all but central pencils we shall thus get a paral-

lactic effect. The suggestion is of value, and it will be seen that paragraph (i) in what follows seems to distinctly support it.

The subject having thus attracted attention elsewhere, and having possibly an important bearing (as Dr. Wislicenus remarks) on heliometer and other observations where object-glasses are sometimes screened, I have thought it advisable to communicate to the Society some further notes which I put together some years ago, but which were laid aside at the time because of the negative character of some of the conclusions, which may be summarised as follows:—

(I.) The systematic difference under discussion, after remaining constant for several years, began to change, and numerically doubled itself. At present there are signs of its returning towards the smaller values.

(II.) No cause can be assigned with certainty for this change. Either the figures of the object-glasses have slightly changed, or, possibly, adopting the above suggestion of Dr. Wislicenus, the eccentricity of the pencil has been changed, and the parallactic effect consequently increased.

(III.) The effect which should be traced on stellar observations is found to be extravagantly too large, pointing to some other disturbing cause.

I proceed now to give the notes nearly as they were drawn up in 1888:—

(α) “Experiments on the effect of the limitation of aperture of the collimators when observations are taken through the central cube of the transit circle having led to the suspicion that the object-glasses of the collimators might be defective, they have been examined by Mr. Simms, who has reported that they are excellent.” (*R.A.S. Council Report*, Royal Observatory, Greenwich, 1887, February; *M.N.*, vol. xlvii. p 149). We are thus not dealing with any defect such as a good optician eliminates in constructing object-glasses.

(β) It is probable that any form of screen would produce some effect on the reading for coincidence. A few experiments were made, not on the two collimators, but with the transit-circle telescope on each of them, using a screen to cover half the object-glass, as follows:—

T.C. on North Collimator.

Excess of Reading of T.C. micrometer with
Screen covering

Date.	Observer.	Whole O.G.	Upper half.	Lower half.	E. half.	W. half.
1886.						
Apr. 20	H. T.	...	·000	—·009	+·006	+·047
1887.						
Feb. 29	H. T.	...	·000	+·004	—·005	+·154
29	H. T.	...	·000	—·013	—·024	+·108
Mar. 3	H. T.	—·004	·000	+·012	+·010	+·082
3	H. T.	+·003	·000	—·004	—·010	+·035

T.C. on South Collimator.

Date.	Observer.	Excess of Reading of T.C. micrometer with Screen covering				
		Whole O.G.	Upper half. r	Lower half. r	E. half. r	W. half. r
1885. Apr. 20	H. T.	...	'000	'000	—'013	+ '014
1887. Feb. 29	H. T.	...	'000	—'014	—'025	+ '037
29	L.	...	'000	—'021	—'029	+ '036
Mar. 3	H. T.	+ '012	'000	—'023	—'018	+ '019
3	H. T.	—'001	'000	—'018	—'004	+ '011

1 rev. of the micrometer = 14''·78.

(γ) The discordance between readings for coincidence of collimators through the cube and with unobstructed view has undergone a curious change in the course of years. The following is a complete list of the mean annual values to date:—

1871	0''58	1878	0''53	1885	0''99
1872	'56	1879	'56	1886	1'14
1873	'56	1880	'61	1887	1'19
1874	'56	1881	'80	1888	1'02
1875	'53	1882	'73	1889	1'21
1876	'53	1883	'87	1890	1'21
1877	'61	1884	'77	1891	0'87

The value was thus sensibly constant for ten years, but has since either been continuously changing, or has suffered two more or less abrupt changes about 1881 and 1885. The following paragraphs give the results of the examination of various hypotheses which might account for this change or changes.

(δ) *Change of Observer.*—It is possible that personality may have some influence on the result. Below are two sets of results collected according to separate observers:—

1877-1879.	No. of Obs.	Discordance.	1882-1887.	No. of Obs.	Discordance.
Lynn	22	0''58	Lewis	38	1'07
Criswick	11	'46	Hollis	61	0'85
Downing	27	'65	Downing	76	0'95
Thackeray	16	'48	Thackeray	13	1'23

Two observers are common to the two sets, and the changes are apparently independent of the observer.

(ε) *Introduction of the Reversion Prism Eyepiece.*—The observations in earlier years had not been reduced in the first instance, and attention was therefore drawn only to the change in 1885. It was at once suspected that this might be due to the introduction of the reversion prism eyepiece, and observations to

compare this with the ordinary eyepiece previously in use were made as follows :—

On 1888 March 1 I took the following readings of N. Coll. on S. Coll. through the cube :—

R.P. Eyepiece.	Mean.	Ordinary Eyepiece.	Diff.
<i>r</i>	<i>r</i>	<i>r</i>	<i>r</i>
·685	·704	·695	·696
·668	·701	·685	·690
·665	·697	·681	·691
			in rev.
			in arc.
			+ ·001
			+ ·005
			+ ·010
			+ 0"02
			+ 0"12
			+ 0"24

Each number in columns 1 and 2 is the mean of three, and in columns 3 and 4 of six observations.

On 1888 March 12 readings were also taken by all the four regular observers with both eyepieces, and both through the cube and with instrument raised, as follows :—

Observer.	Excess of reading through Cube.		Diff. R.P. — O.
	R.P. Eyepiece.	Ordinary Eyepiece.	
H. T.	+ 1"11	+ 1"40	— 0"29
A. D.	+ 0"87	+ 0"90	— 0"03
T.	+ 0"24	+ 0"99	— 0"75
L.	— 0"22	+ 0"31	— 0"53
H.	+ 0"44	+ 0"65	— 0"21
Mean	+ 0"49	+ 0"85	— 0"36

Thus the correct use of the R. P. eyepiece will certainly not explain an *increase* in the discordance.

(ξ) It was suspected, however, that the position of the prism in front of the aperture of the eye-lens might have some influence on the results. It had occasionally been found out of adjustment, being held only by a single screw, round which as a centre it was liable to be rotated. The limit of displacement which might be unnoticed by the observer is, on one side a position when enough light comes through the uncovered portion of the eye-lens to give a second image of the field of view (1); and on the other side a position where some phenomenon of total reflexion occurs and the field becomes quite dark (2). Between positions (1) and (2) is that of good adjustment, which we may call (3). On 1888 March 12 the following observations of N. Coll. on S. Coll. were taken with the prism in these three positions.

Observer.	Reading of N. Coll. Micr.		
	Position (1).	Position (3).	Position (2).
H. T.	·664	·660	·645
H. T.	·665	·667	·634
H. T.	·663	·670	·636
L.	·618	·615	·605
H.	·616	·623	·596
Mean	·645	·647	·623

Thus if the prism is out of adjustment towards the position (1) the readings are not sensibly affected, but towards the position (2) the readings of N. Coll. micr. are spuriously diminished. Thus, as before, an *increase* in the discordance under examination cannot be explained by bad adjustment of the prism.

(η) *Changes of position of the Collimators with reference to the Central Cube.*—The most important change in the mounting of the collimators was made early in 1882, when they were mounted on two pivoted stalks so that they could be turned aside to allow of a greater range of reflexion observations with the transit circle. An inspection of the annual results for the years immediately preceding and following 1882 shows that this change did not affect the discordance under discussion. There have been, however, slight changes in relative azimuth, and possibly slight lateral shiftings of the axis of one or all three telescopes. After the Y's of the transit circle telescope had been taken out and cleaned early in 1888, it was found that the telescope went back into a sensibly different position, closer to its western pier, towards which it is pressed by a spring. Small pieces of dirt had been accumulating for years on the western bearing, and the removal of these allowed of a slight lateral shift. This of course would alter the exact position of the interposed cube with reference to the collimator object-glasses.

Changes in relative azimuth, both periodic and secular, are known to occur, though their total amount is very small—probably less than a minute of arc; and it does not seem likely that changes of this magnitude would affect the results. But both these possible causes were considered.

(θ) *Lateral Shiftings.*—The wooden model of the cube was alternately placed in two positions separated by about $\frac{1}{2}$ -inch in the E. & W. direction, and readings of the transit-circle micrometer were taken for coincidence with the N. Collimator on 1888 March 15.

Observer.	No. of Obs.	Cube.		E. - W.	In arc.
		East.	West.		
H. T.	10	·331	·348	—·017	—0"25
H. T.	10	·364	·372	—·008	—0"12
H. T.	10	·356	·361	—·005	—0"07
H.	10	·304	·340	—·036	—0"53
H.	10	·310	·352	—·042	—0"62
Mean		·333	·355	—·022	—0"32

There seems to be, therefore, a small effect due to lateral shift; but half an inch is probably a much larger quantity than any which occurred in actual fact.

Under this head I may remark that observations are some-

times made through the cube with the transit-circle telescope pointing vertically upwards instead of vertically downwards. Any slight want of symmetry of the aperture with respect to the optical axis of the collimators might cause a difference between the two methods. Observations by Mr. Miskin on 1891 December 29 seem to show that there is no sensible difference. Mean readings of N. Coll. micr. as follows:

	O.G. up.	O.G. down.
	^r .566	^r .568
	.603	
	.581	.600
Mean	.583	.584

Each number being the mean of six readings.

(1) *Changes of Azimuth.*—The wire system in each of the collimators consists of two pairs of wires at right angles, forming at their crossing a square whose side is about 85". If the discordance under consideration vary with the position in the field of view (as would follow, for instance, from Dr. Wislicenus' suggestion), it should be different for bisections made with opposite sides of the squares, which is equivalent to changing the relative azimuth by 170"—a much larger quantity than could correspond to any secular change. The following comparisons were made on 1888 March 12:

Observer.	No. of Obs.	Right of Square.	Left of Square.	Diff.	Diff. in arc.
H. T.	10	^r +0.094	^r +0.083	^r +0.011	+0.26
H. T.	10	+0.072	+0.042	+0.030	+0.73
H. T.	10	+0.074	+0.045	+0.029	+0.70
T.	6	+0.082	+0.072	+0.010	+0.24
H. T.	10	+0.057	+0.058	-0.001	-0.02
H. T.	10	+0.041	+0.031	+0.010	+0.24
Mean		+0.070	+0.055	+0.015	+0.36

From 1877 to 1882 the common azimuth of the collimators was nearly always less than 10" from the meridian. At the end of 1882 the screws of the S. Coll. apparently got loose, and the deviation from the meridian became large and irregular. The screws were tightened on 1883 May 9. Since then the azimuth of the S. Collimator has gradually changed, as follows:

"	7	at the end of	1883
22	"	"	1884
22	"	"	1885
26	"	"	1886
40	"	"	1887

On 1888 January 18 the object-glasses of the collimators were taken out and cleaned. On restoring them the azimuth of the S. Coll. was found to be reduced to 30".

It was

"	27	at the end of	1888
24	"	"	1889
27	"	"	1890
20	"	"	1891

The removal of the object-glasses for repolishing in 1891 August did not affect the continuity of the results.

There were new wires inserted in

N. Coll.	S. Coll.
on 1874, June 29	1874, Nov. 9
1881, Jan. 31	1882, Dec. 25
1884, June 16	1883, March 13

(κ) *The Effect of the Discordance on Stellar Observations.*—An erroneous determination of collimation would involve erroneous level, azimuth, and clock errors. It is easy to show that an error of c'' in collimation ultimately affects the R.A.'s of stars by $\frac{c''}{15} \tan \frac{1}{2} \text{N.P.D.}$ Now the observations for collimation have been partially corrected for the discordance under consideration, adopting the numerical value deduced from observations in the early years. For various reasons this constant was not changed even when it was found that the mean annual value of the discordance had increased to nearly twice its original amount. Thus the R.A.'s of stars in the years subsequent to 1880 should be increased by $k \tan \frac{1}{2} \text{N.P.D.}$, where k may be taken as 0^s.008 for 1881–1884, and 0^s.020 for 1885–1890. To test the reality of this correction, a comparison of the R.A.'s of stars deduced from observations above and below pole in the years 1877–1883 was made, and a similar comparison for the years 1885–6. The difference between the two series should require a correction readily deducible from the above theoretical expression, and tabulated in the fifth column of the following table. It will be seen that the observed differences are extravagantly larger than the theoretical, although of the same sign; and point to some other disturbing cause.

Limits of N.P.D.	Mean Excess of R.A. above Pole.		Diff.	Theoretical difference.
	1877-1883.	1885-6.		
$\overset{\circ}{1}-\overset{\circ}{5}$	$\overset{s}{+}^{\cdot}555$	$\overset{s}{+}^{\cdot}269$	$\overset{s}{+}^{\cdot}286$	$\overset{s}{+}^{\cdot}001$
5-10	$\overset{s}{-}^{\cdot}047$	$\overset{s}{-}^{\cdot}244$	$\overset{s}{+}^{\cdot}197$	$\overset{s}{+}^{\cdot}003$
10-15	$\overset{s}{-}^{\cdot}139$	$\overset{s}{-}^{\cdot}253$	$\overset{s}{+}^{\cdot}114$	$\overset{s}{+}^{\cdot}005$
15-20	$\overset{s}{+}^{\cdot}264$	$\overset{s}{-}^{\cdot}244$	$\overset{s}{+}^{\cdot}508$	$\overset{s}{+}^{\cdot}006$
20-25	$\overset{s}{+}^{\cdot}005$	$\overset{s}{-}^{\cdot}141$	$\overset{s}{+}^{\cdot}146$	$\overset{s}{+}^{\cdot}007$
25-30	$\overset{s}{-}^{\cdot}001$	$\overset{s}{+}^{\cdot}002$	$\overset{s}{-}^{\cdot}003$	$\overset{s}{+}^{\cdot}009$
30-35	$\overset{s}{+}^{\cdot}026$	$\overset{s}{-}^{\cdot}077$	$\overset{s}{+}^{\cdot}103$	$\overset{s}{+}^{\cdot}011$
35-40	$\overset{s}{+}^{\cdot}023$	$\overset{s}{-}^{\cdot}063$	$\overset{s}{+}^{\cdot}086$	$\overset{s}{+}^{\cdot}013$
40-45	$\overset{s}{+}^{\cdot}005$	$\overset{s}{-}^{\cdot}155$	$\overset{s}{+}^{\cdot}160$	$\overset{s}{+}^{\cdot}015$
45-50	$\overset{s}{-}^{\cdot}019$	$\overset{s}{-}^{\cdot}069$	$\overset{s}{+}^{\cdot}050$	$\overset{s}{+}^{\cdot}017$

On the other hand, the reflexion observations seem to agree well with theory. These are discussed annually, as "Corrections to Adopted Level Errors," in the Greenwich volumes; and the weighted mean correction for the years 1882-3 is $-0''\cdot28$, while that for 1885-6 is $+0''\cdot19$, exceeding the former by $+0''\cdot47$. According to the formula given above, this quantity should be $+0''\cdot57$.

A New Photographic Photometer for determining Star Magnitudes.
By W. E. Wilson.

I would like to bring before the notice of the Society the design of an instrument which I think will be of use in stellar photography, and especially in determining photographic magnitude of stars.

The instrument consists of a photographic plate and holder ($6\frac{1}{2}$ in. $\times$ 1 in.), moving in a slide in the direction of its greatest length. A spiral spring tends to pull the holder to one end of the slide, and a simple electro-magnetic escapement each time the magnet is excited allows the spring to advance the plate and holder $\frac{1}{10}$ inch. The entire apparatus screws into the eye-end of a photographic telescope.

A star whose magnitude is to be determined is focussed close to the end of the photo plate, and an exposure of say 100^s given. The magnet is then excited for a moment by the current from a contact-maker, driven by a clock; the plate moves forward suddenly $\frac{1}{10}$ inch, and a second exposure is given, which lasts only 63^s . Again the plate moves forward to give a third exposure of $39^s\cdot8$, and the exposures are thus continued in the above ratio until they are reduced to 1^s . The telescope is then set on a standard star, such as *Polaris*. The holder is moved back to its original position, and *Polaris* is placed $\frac{1}{10}$ inch below

the first exposure of star No. 1. The same series of exposures are then given, and the plate developed. The result will be like this:—

Polaris = ● ● ● ● ● ● ● ● ● ● ● ● ● ● ● ●
 Star No. 1 = ● ● ● ● ● ● ● ●

The relative number of images of the two stars will give their magnitudes to 0.5. The times of exposures will vary as the number whose log. is 0.2, but there is no reason why they should not be made to give 0.1 magnitudes.

The contacts are made by a wooden disc, revolving uniformly by the driving clock of the equatoreal. On its edge are brass pins, which are placed so as to pass under a wiper at the correct intervals. The entire process is automatic once the star is set in its right place. Each plate will hold ten sets of exposures.

The instrument will also be of use for determining the actinic value of the sky before taking a stellar photograph. In this case, by taking a series of *Polaris*, and finding thus at what exposure it fails to record itself, the exposure necessary to record a star of another magnitude will be known.

Also, to determine the value of wire screens in front of the O.G., a series can be taken with and without the screen and the necessary value found.

I hope to exhibit some negatives taken with the instrument shortly before the Society.

1892 January 3.

The Red Stars in the Great Perseus Clusters.

By the Rev. T. E. Espin, B.A.

Although the fact that there are several red stars in G.C. 512,521 is well known, as far as I am aware their actual places have never been published, with the exception of one or two of the brighter ones. Herschell and D'Arrest each saw one, Smyth two, Birmingham three, Rev. T. W. Webb five, Rev. T. T. Smith eight. The "Observations of Nebulæ and Clusters at Birr Castle" (*Scientific Transactions of the Royal Dublin Society*, vol. ii., New Series, p. 27) mention five. As there seemed to be considerable divergence of opinion as to their number, the clusters were carefully examined on the nights of 1891 December 29 and 1892 January 1. The powers used were the sweeping power of 70, and a power of 200. The first night was remarkably fine, and the definition superb, and the sky intensely black. While examining the P cluster (G.C. 512) I had a strong suspicion that the N.P. part was nebulous. The eye-pieces were carefully cleaned,

and the telescope moved rapidly backwards and forwards, and a decided impression was left upon my mind that there is really some faint nebosity in that part. The second night, January 1, the definition was poor, and no nebosity was seen. No red stars were seen in G.C. 512, four lie between the clusters, three are found in G.C. 521, the remaining two among the outliers. The spectroscopic observation of the stars in the cluster is difficult, the spectra overlapping each other. The stars are all third type, and very similar to one another; the colours are nearly similar, the magnitudes also. The following table gives the D.M. number of the stars, the place, the D.M. magnitude, the observed magnitude, and the spectrum:—

	D.M.	R.A. II h. (1855)	Decl.	Magnitude.		Colour.	Spect.
				D.M.	Observed.		
(1)	+ 56 512	^m 8 ^s 40	+ 56° 45' 2"	9.0	8.8	OR	III.
(2)	56 547	10 19	56 19.4	8.2	7.6	OR'	III.!
(3)	56 551	10 45	56 29.3	8.2	7.8	OR	III.
(4)	57 550	11 26	57 11.1	8.5	8.5	OR	III.
(5)	55 597	11 58	55 56.2	8.2	7.0	OR	III.!
(6)	56 583	12 12	56 26.3	8.6	8.2	OR'	III.
(7)	56 595	12 57	56 32.0	8.5	8.4	OR'	III.
(8)	56 597	13 9	56 32.7	8.6	8.5	OR	III.!
(9)	56 609	15 3	56 46.8	8.4	8.8	OR	III.!

It is obvious that the observed magnitudes are overrated, and, rejecting No. 2 and No. 5, a correction of +0.2 is found. No. 2 seems to be actually underrated in Argelander. Mr. Pihl, in *The Stellar Cluster χ Persei*, makes it 7.8, and in the *Neue Annalen der k. Sternwarte in Bogenhausen*, Band ii., in a study of 38h. *Persei*, Dr. Oertel gives it as 7.6. As regards the star No. 5, I suspect from the great difference of magnitude that it may be variable. The first observation of it was on December 22, when it was rated as 7.0; on December 29 it was again observed, and compared with No. 2, when it was estimated as 7.4. On both nights the fainter stars were carefully examined, and, had there been any other red star above magnitude 10.5, it could not have escaped detection.

Tow Law:
1892 January 6.

On the Phenomenon of the Transit of the First Satellite of Jupiter 1890 September 8, and Observations of the Red Spots on the Planet. By E. E. Barnard, M.A.

In a letter which I have received from Mr. A. Stanley Williams he informs me that he has sent a communication to the Royal Astronomical Society in which he endeavours to explain the apparent duplicity of the first satellite of *Jupiter* at its transit 1890 September 8, by supposing the phenomenon to have been a close conjunction of the satellite with a small spot which he had seen three days earlier on the planet.

Leaving aside the fact that it is wholly improbable that two experienced observers should have been so mistaken in a matter of this kind, I would say that the phenomenon of apparent duplicity was watched for upwards of half an hour before the visitors interrupted (from before sidereal $18^h 30^m$ to about $19^h 7^m$), part of which time Mr. Burnham observed with me. During that interval no relative motion was detected. At the transit of I, the relative motion of the satellite and a spot on *Jupiter* would have amounted to $0''.15$ each minute of time—a displacement which would have been only too apparent in a few minutes with the 12-inch and the high magnifying power employed. It is, therefore, apparent that Mr. Williams's explanation can have no bearing on the apparent duplicity of Satellite I at its transit 1890 September 8.

I consider the observation of the double transit an important one, the explanation of which will perhaps be still more important.

It should be accepted as unquestionable that the phenomenon of 1890 September 8 was wholly connected with the satellite. One or the other of the two probable explanations which I have given in *Monthly Notices*, No. 9, vol. li., will doubtless be found in the end to be the true solution of the matter. It is unfortunate that the transits of this object still occur over a dark portion of *Jupiter*. As soon as these are transferred to a bright region we may expect to know something more definite.

The New Red Spot in the Southern Hemisphere.

The new red spot, which has been such a striking feature in the southern hemisphere of *Jupiter* during the past opposition, has disappeared. About the last of October it was the most prominent feature on the planet. It was well defined and of a clear red, very much resembling in distinctness and colour the appearance of the great red spot in 1880. In the first part of November it began to fade quite rapidly, and by the 20th was scarcely discernible.

On December 14 no trace of it could be made out with any certainty.

On November 20, 8^h 2^m.0, Mount Hamilton mean time, it was in transit, and its longitude was 110°9.

The Great Red Spot.

This object seems again to be slackening its rate of rotation. During the past opposition its longitude remained quite constant at about 3°. Its longitude is now increasing. A transit on December 14, 5^h 5^m.3, gave the longitude = 6°4. It is now very much more conspicuous than at opposition, and is a stronger red in colour.

Mount Hamilton :

1891 December 17.

Reappearance of Saturn's Ring, and Position Angle before the disappearance, observed at the Observatory, Utrecht. By Professor J. A. C. Oudemans.

The telescope of the Utrecht Observatory has an object-glass of Jacob Merz, aperture 0.260 metre; focal distance 3.200 metres. The eyepiece employed was a positive one of Steinheil, with a magnifying power of 162.

1891 October 28, 18^h, M. T., Utrecht. Hazy. *Saturn* decidedly without ring.

1861 October 29, 17^h 30^m. M. T., Utrecht. Clear. *Saturn* decidedly without ring. A thin dark line crosses the disc along the equator.

1891 October 30, 16^h–19^h. Overcast.

1891 October 31, 17^h 30^m. Clouds. *Saturn* visible for a moment; at both sides the ring is visible as a thin bright line.

1891 November 1, 17^h–19^h. Overcast.

1891 November 2, 17^h 15^m. M. T., Utrecht. Clear; a little hazy. Ring clearly visible; very beautiful, with the feeblest magnifying power 114. The dark line across the planet still visible. It seems to me that this dark line must be the dark ring.

I give these observations without comment, judging it better to wait for other observers' results.

After a careful discussion I adopted for the fourth edition of Kaiser's *Sterrenhemel* the following values of the dimensions of *Saturn* and his rings at the mean distance 9.53885 (see that Work, ii. p. 701):

	Diameter.	Semidiameter.
Outer ring, exterior	39 ^{''} 5	19 ^{''} 75
Inner ring, interior	27 ^{''} 5	13 ^{''} 75
Dusky ring, interior	21 ^{''} 8	10 ^{''} 9
Equatorial	17 ^{''} 3	8 ^{''} 65
Polar	15 ^{''} 4	7 ^{''} 7

If the mass of the bright rings is supposed to be $\mu \times$ the mass of the planet, and if the ring's density is supposed to be the same as *Saturn's*, we deduce from these numbers that the thickness of these rings is 3^{''}·82 μ .

With $\mu = \frac{1}{118}$ (Bessel) this becomes 0^{''}·0324

„ $\mu = \frac{1}{314}$ (H. Struve) „ „ 0^{''}·0121

The Sun, seen from *Saturn*, presents itself as a disc of 32' : 9'53885 = 3'·355, and the distance of the interior diameter of the interior bright ring being 13^{''}·75 - 8^{''}·65 = 5^{''}·1, as long as both the sides of the ring have sunshine,* the remaining shadow of the rings on the planet is

$$\left. \begin{array}{l} 0^{\prime\prime}0324 \\ \text{or } 0^{\prime\prime}0121 \end{array} \right\} - 5^{\prime\prime} \cdot 1 \sin 3^{\prime} \cdot 355 = \left. \begin{array}{l} 0^{\prime\prime}0324 \\ \text{or } 0^{\prime\prime}0121 \end{array} \right\} - 0^{\prime\prime} \cdot 0050 = \left\{ \begin{array}{l} 0^{\prime\prime}0274 \\ \text{or } 0^{\prime\prime}0071 \end{array} \right.$$

whereas, according to Bessel's elements, adopted in the *Nautical Almanac*, the earth's elevation above the ring's plane was

$$\begin{array}{rcl} \text{on Oct. 28} & \overset{h}{18} \text{ M.T.Gr.} & \overset{o}{1} 57^{\prime}7 \\ \text{Nov. 2} & 18 \text{ „} & 2 \ 8^{\prime}5 \end{array}$$

We will take the mean 2° 3'·1; so the breadth of the dusky ring near to the centre of the planet is 2^{''}·85 sin. 2° 3'·1 = 0^{''}·102; however small this number be, it is much larger than either 0^{''}·0274 or 0^{''}·0071, the breadth of the ring's shadow on the planet, adopting either Bessel's or H. Struve's mass of the ring.

* The Sun's elevation changes 18'·4 in 20 days, i.e. 0'·92 in a day, so the time during which both sides of the ring have sunshine is about 3 $\frac{1}{2}$ of our days.

Position-Angles of the Ring, measured with the wire micrometer.

1891.	M.T. Utrecht.	Pos. Angle.	Naut. Alm.	Corr. of N.A.
	^h ^m	[°] [']	[°] [']	
June 24	8 57.5	-5 15.0 (5)	-5 34.7	+ 19.7
26	8 44.7	-5 11.0 (4)	-5 34.1	+ 23.1
28	8 51.5	-5 6.5 (5)	-5 33.45	+ 26.95
July 4	8 43	-5 48.0 (5)	-5 31.4	- 16.6
5	8 37.5	-5 26.5 (5)	-5 31.0	+ 4.5
10	8 24.6	-5 41.5 (3)	-5 29.0	- 12.5
July 1	12 43.1	-5 24.7	-5 32.3	+ 7.6
= 12 22.6 M.T.Gr.				

The numbers in brackets indicate the numbers of measures, which, however, have not been taken into account in deducing the mean.

Utrecht :

1891 December 14.

Observations of Occultations of Stars by the Moon, and of Phenomena of the Satellites of Jupiter and Saturn, made at Mr. E. Crossley's Observatory, Bermerside, Halifax, in the year 1891.
By J. Gledhill.

Lunar Occultations.

1891 January 17.—ξ *Arietis*. Disappearance, G.M.T., 11^h 3^m 20^s.5. Time by *N. Almanac*, 11^h 5^m. Definition not good.

1891 March 26.—l² *Virginis*. Disappearance, 10^h 3^m 8^s. Time by *N. Almanac*, 10^h 1^m. Stormy.

1891 April 18.—42 *Leonis*. Disappearance, 10^h 27^m 56^s. Time by *N. Almanac*, 10^h 35^m.

Phenomena of Jupiter's Satellites, observed with the 9½-inch Cooke Equatorial Refractor.

Date.	Satellite and Phenomena.	G.M.T. of Observation.	Time by Nautical Almanac.
1891.		^h ^m ^s	^h ^m ^s
Aug. 22	I. Ec. D. Began to fade.	10 6 30	10 10 17
	Half gone.	10 8	
	Last seen.	10 10 58	
29	I. Ec. D. Began to fade.	12 3	12 5 14
	Half gone.	12 4 30	
	Last seen.	12 5 45	

Date.	Satellite and Phenomena.		G.M.T. of	Time by
			Observation.	Nautical
			h m s	Almanac.
1891.				h m s
Sept.	6	I. Tr. I.	Outer contact.	11 9
			Bisection.	11 11 30
			Inner contact.	11 13 30
	8	II. Tr. E.	Inner contact.	10 43
			Bisection.	10 45 30
			Outer contact.	10 47
		II. Sh. E.	Inner contact.	10 55
	10	III. Tr. E.	Half off.	10 49
			Just off.	10 52
	28	IV. Ec. R.	First seen.	11 47 1
	29	I. Tr. I.	Outer contact.	10 47
			Inner contact.	10 50
		I. Sh. I.	Just within disc.	11 26
	30	I. Ec. R.	First seen.	10 58
			Full.	11 3
Oct.	7	I. Oc. D.	First contact.	9 50
			Half gone.	9 52
			Just gone.	9 54
		I. Ec. R.	First seen.	12 53 43
	9	I. Ec. R.	First seen.	7 22 27
	10	II. Tr. I.	First contact.	6 14
			Half on.	6 16
			Just within.	6 18
	12	III. Cc. D.	First contact.	10 28
			Bisection.	10 31
			Just gone.	10 34
	15	I. Tr. I.	First contact.	8 46 30
			Bisection.	8 48
			Just within.	8 50
	16	I. Ec. R.	First seen.	9 17 53
			Full.	9 22
	19	II. Ec. R.	First seen.	7 37 59
			Full.	7 42
	23	IV. Tr. E.	Half off.	6 48
			Outer contact.	6 50
		III. Tr. E.	Half off.	7 10
			Outer contact.	7 18

Jan. 1892.

Jupiter's Satellites, 1891.

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Date.	Satellite and Phenomena.	G.M.T. of Observation.	Time by Nautical Almanac.
1891.		h m s	h m s
	I. Oc. D. Outer contact.	7 50	7 53
	Just gone.	7 55	
	I. Ec. R. First seen.	11 13 47	11 13 17
	Full.	11 18	
Oct. 24	I. Sh. I. Just within.	6 9	6 6
	I. Tr. E. Half off.	7 17	7 20
	Outer contact.	7 20	
	I. Sh. E. Inner contact.	8 20	8 24
	Half off.	8 24	
30	III. Tr. I. First contact.	7 28	7 27
	Bisection.	7 31	
	Inner contact.	7 35	
Nov. 2	II. Oc. D. First contact.	7 36	7 39
	Bisection.	7 38	
	Just gone.	7 40	
17	III. Oc. R. Outer contact.	8 22	8 21
20	II. Ec. R. First seen.	7 24 12	7 23 26
	Full.	7 29	
Dec. 2	I. Tr. E. Outer contact.	5 43	5 39
4	II. Oc. D. Contact.	7 7	7 7
	Just gone.	7 10	
6	II. Sh. I. Inner contact.	5 5	5 2
	II. Tr. E. Outer contact.	5 12	5 10
16	III. Ec. R. First seen.	5 37 17	5 36 44
	Full.	5 40	
17	I. Ec. R. First seen.	8 8 12	8 9 26
22	II. Ec. R. First seen.	7 13 7	7 12 51
	Full.	7 17	
29	II. Oc. D. Contact.	4 31	4 34
	Last seen.	4 34	

Notes.

August 22.—Planet low. Much motion.
 September 6.—Definition poor. Too much motion for any useful observation of the transit of the shadow.
 September 8.—Cloudy. Poor definition. Impossible to see when the shadow was just off the disc.
 September 10.—Planet too low for the first two observations given in the N.A. Definition bad. The shadow of III was a very striking object during its transit.
 September 28.—Furious wind. Often cloudy.

- September 29.—Bad night. Cloudy and windy. Clear now and then.
 September 30.—Fair definition.
 October 6.—Very bad sky.
 October 7.—Very good definition, but seldom clear.
 October 10.—Fair sky.
 October 12.—Pretty good definition.
 October 15.—Furious wind. Very bad definition. The sky cleared suddenly at 8.30 P.M.
 October 16.—Poor definition.
 October 19.—Much motion.
 October 23.—Fair definition.
 October 24.—Bad sky.
 October 30.—Calm. Very misty. Steady images.
 November 2.—Good definition.
 November 17.—Violent motion.
 November 20.—Good sky.
 December 2.—Bad definition. Power 150. Definition not good enough for observing the shadow.
 December 4.—Much motion.
 December 16.—Violent motion.
 December 22.—Misty.
 December 6.—Much motion.
 December 17.—Misty.
 December 29.—Stormy.

Dark Transits of Jupiter's Satellites &c.

1891 September 29.—I began its transit about 10^h 48^m. It soon faded away and was invisible at 11^h 15^m; also at 11^h 40^m.

1891 October 6.—Sky began to clear at 10.30 p.m.

IV was near the limb at 11^h and quite grey. It was in outer contact probably about 11^h 30^m. Very bad sky.

At 11^h 30^m I was near the limb and much fainter than it was at 11^h.

1891 October 7.—I was quite bright up to its disappearance.

1891 October 10.—II did not appear to lose brightness as it approached the limb of *Jupiter*. When just on the disc it was a bright object. Was invisible at 6^h 40^m, 7^h 15^m, and 7^h 30^m.

1891 October 12.—III did not appear to lose brightness as it approached the planet.

1891 October 15.—I is not as bright as the limb of the planet. IV and II appear much less bright than III.

1891 October 23.—5^h 30^m *Jupiter* low; misty. IV in transit, and as dark as a shadow. III is also in transit; is smaller and not so dark as IV. The former is projected against a southern grey band; the latter is in a southern bright zone.

III was central about 5^h 30^m.

6^h 30^m, both satellites dark as above, IV being not far from the limb.

6^h 45^m, IV invisible. III is dark yet.

6^h 48^m, IV half off and as bright as the limb of the planet.

6^h 50^m, III faint. At 7^h 5^m IV looked dim and strikingly less bright than I, which was approaching the disc. III invisible. At 7^h 10^m III was half off and quite as bright as the limb. When III and IV got away from the limb into the dark sky, their difference in size and brightness was very striking. The two were near together.

1891 November 17.—8^h 30^m, IV is strikingly faint, although it is not far (about $\frac{1}{4}$ of the diameter of *Jupiter*) from the limb.

1891 December 2.—I will come off the disc at 5^h 39^m. It is now (5 P.M.) invisible, but the shadow is well seen. The satellite was not seen till nearly in inner contact, when it was about as bright as the limb of the planet, and it was very faint after it passed off the disc.

1891 December 4.—II was near the planet at 7^h, and grew faint as it approached the limb.

1891 December 5.—III dark during transit. At 5^h dark but not black. So also at 5^h 30^m. Invisible at 6^h. Egress at 6^h 21^m not seen owing to wind and cloud.

1891 December 6.—II in transit. Invisible at 4^h 50^m and at 5^h.

1891 December 16.—I in transit. At 8^h invisible. At 9^h seen as a grey spot.

1891 December 22.—II became very faint as it approached the planet at 4^h 20^m and 4^h 30^m.

IV began its transit at 2^h 36^m. At 4^h and 4^h 30^m and 5^h it was a dark grey, large, diffuse spot and not circular. It was not visible at 6^h 15^m, nor at 6^h 30^m. Clouds prevented further observation.

Phenomena of Saturn's Satellites.

The weather in January and February was very bad, and no observations could be obtained.

1891 March 12.—Fair definition. Watched *Enceladus* near east end of ring. At east elongation at 10^h.

Tethys pn. Just under western end of ring. Not up at 9^h 15^m; past at 9^h 20^m.

Enceladus ps. Very difficult owing to cloud. Up between 10^h 20^m and 10^h 28^m; past at 10^h 30^m.

1891 April 16.—Bad sky. *Rhea* w. Up between 8^h 50^m and 9^h 5^m; thought to be in line at 9^h.

Tethys w. Not up at 11^h 40^m; past at 11^h 52^m. Up between 11^h 45^m and 11^h 50^m.

1891 April 17.—*Tethys* e. Misty. Satellite seen occasionally; judged in line between $10^h 10^m$ and $10^h 20^m$.

Enceladus very difficult owing to mist in air. Judged in line at $11^h 55^m$.

1891 April 22.—*Tethys* ps. In line with end of ring between $11^h 20^m$ and $11^h 30^m$.

1891 May 4.—*Rhea* w. Saw satellite occasionally. Nearly up at $10^h 25^m$.

1891 April 23.—*Tethys* fn. Up at $10^h 15^m$.

Observations of Occultations of Faint Stars during the Total Eclipse of the Moon on 1891 November 15, made at the Royal Observatory, Cape of Good Hope.

(Communicated by David Gill, LL.D., F.R.S., H.M. Astronomer at the Cape of Good Hope.)

In compliance with the request of Professor Döllén, conveyed by letter, preparations were made for observing the occultations of faint stars by the Moon during its total eclipse on November 15. Professor Döllén's circular, which accompanied his letter, gave the predicted Greenwich mean times of eleven disappearances and eight reappearances which might be observed at the Cape, together with the data for checking the accuracy of the predicted phenomena. These predictions, which had been obtained by a graphical process, were recomputed and found to be correct. The largest available instrument at this Observatory—the 10-inch guiding telescope of the photographic equatorial—was used by Dr. Gill. The eye end of this instrument is fitted, not with the usual position micrometer, but with an eye-piece mounted on two slides at right angles to each other, by one of which the eye-piece can be displaced from the axis nearly $1^\circ +$ or $-$ in declination, and by the other to the same amount east or west of the axis. The amount of displacement is read off by finely divided scales. It was thus necessary to provide means for keeping the centre of the Moon coincident with the axis of the telescope, so that the centre of the eye-piece could be set by means of the scales (the proper readings having been previously computed) to the precise point of disappearance, and specially of reappearance of the star at the Moon's limb.

For this purpose an eye-piece of 2 inches focal length was adapted to the cover of the dark slide of the photographic telescope. The field of this eye-piece was about 34 inches in diameter, so that Mr. Woods found no difficulty, with the aid of the slow motions in R.A. and Decl., in keeping the Moon's centre in coincidence with the axis of the telescope during

the whole period of totality, and thus the phenomena were observed in every case precisely at the expected point.

The sidereal clock of the photographic observatory has a very feeble beat, and as the contingency of a high wind had to be faced (and, in fact, was blowing during the eclipse), the phenomena were observed not by the beat of this clock, but by the beat of a galvanic 'sounder,' actuated by the same relay as that which actuates the chronograph of the transit circle. Half an hour before totality the sidereal clock in the photographic observatory was set to exact coincidence with the beat of the sounder (the sixtieth second being identified by a missing beat), so that the observer had no difficulty in 'picking up the second' from the clock face at any moment. For further certainty the observer repeated aloud the seconds of his count, which was thus controlled by Mr. Power, who acted as clerk, and who recorded the times of observed phenomena dictated by the observer, and immediately afterwards indicated the settings of the scales for the next star. This method of observation left nothing to be desired. All possible errors of comparing clocks were entirely avoided, and the loud sharp beats of the sounder gave a certainty and precision to the observations which one must experience in order to realise. I am convinced that phenomena like occultations can be more accurately observed in this way than by chronographs, as (in the case of reappearances particularly, and specially in those of very faint stars) one sees at the expected point 'something' of which one notes the instant mentally; but it is necessary to wait a sensible time before one is *sure* that the desired phenomenon was observed. This is more particularly the case when (as on November 15) the definition is very bad—the Moon's limb undulating greatly, and the true phenomena of reappearance take place always within the apparent border of the limb. On account of the very unfavourable quality of the definition the lowest power, 120 diameters, had to be employed.

Mr. Finlay observed with the 7-inch Merz equatoreal, which is fitted with a position circle and filar micrometer by Repsold. The position circle and the wires are illuminated by light from a single fixed incandescent electric lamp, so that successive position angles can be pointed with great rapidity. Mr. Finlay has used this instrument for a very long series of observations of comets and occultations, and preferred to adopt his usual habit of employing the beats of a chronometer, which is compared before and after observation with the Transit clock. The lowest power, 120, was used on account of the bad state of the atmospheric conditions.

Mr. Finlay's observations were recorded by Mr. Cochrane.

Mr. Pett observed with the 6-inch Grubb equatoreal, which was fitted with a micrometer by Troughton and Simms, having bars instead of spider lines, which enable the position-angle on the Moon's limb to be accurately pointed without artificial illumination. The micrometer is provided with only two eye-pieces,

one magnifying 90, the other 230 diameters. Of these Mr. Pett preferred to use the higher power, with which, however, the star images were very diffused, especially so during the latter half of totality.

Mr. Pett's observations were recorded by Mr. Woodgate.

Mr. Cox observed with the heliometer. There are four intersecting metal bars forming a square in the field of view; the centre of this square marks the optical axis. Two sides of the square are parallel to the motion of the slides. One of the other wires (at right angles to the motion of the slide) was used to cut off the required segment of the Moon's limb. This wire is identified by its parallelism to a micrometer screw in the eye-piece, which has special functions that need not here be referred to. By simply setting the position-circle of the heliometer to the required position-angle, the observer was enabled to find with certainty the required point of the Moon's limb. The optical centres of the segments of the object-glass were very carefully adjusted to exact coincidence, so that the instrument was practically used as an ordinary telescope of $7\frac{1}{2}$ inches aperture, with the exception that the telescope itself was revolved about its axis instead of the micrometer only being so. Mr. Cox employed an eye-piece magnifying 155 diameters; his observations were recorded by the beats of a sounder, the same being actuated by the Transit clock relay in the same manner as in Dr. Gill's observations, Mr. Goodman acting as clerk.

The relative positions of the various telescopes to the Transit circle and the heights of the object-glasses above sea-level at mean epoch of the eclipse are—

	From Transit Circle.		Height above sea-level.
Photographic Equatoreal	450 feet S.	130 feet E.	57 feet
7-inch Equatoreal	200 „ N.	145 „ W.	45 „
6 „ „	370 „ S.	50 „ E.	59 „
Heliometer	200 „ N.	60 „ E.	55 „

The following Table gives the sidereal times of the various phenomena as determined by the different observers:—

Star's No.	Mag.	Phenomenon.	GILL. h m s	FINLAY. h m s	PERT. h m s	COX. h m s
(42)		D	4 23 46.3	...	...	...
Probably			(South of $\star$ No. 40.)			
40	10-11		4 27 37.4	4 27 39.4	4 27 37.9	4 27 37.3
25	9.5	R	4 35 17.3	Not certain.	Sharp disappearance.	
			Bad observation.	Star not seen.	Not seen till clear of limb.	Not seen till too late.
38	10-11	D	...	...	...	...
46	9.5	D	...	Star not seen.	...	...
31	9.0	R	4 40 23.8	4 40 35.2	4 40 23.3	...
			Very good; star within moon's limb	Very good; star within moon's limb when first seen.		
				[Note probably miscounted 10 secs. D.G.]		
51	11	D	Lost before reaching limb.	Cloud passing at time.	Lost sight of when nearing limb.	Too faint.
50	11	D	4 57 9.0	Cloud passing at time.	Lost sight of near limb.	Too faint.
34	10-11	R	5 8 19±	5 8 16.6	...	...
58	11	D	Too faint.	Star not seen.	...	Too faint.

Star's No.	Mag.	Phenomenon.	GILL.	FINLAY.	PETT.	COX.
54	9.2	D	h m s 5 11 35.2 Def. bad; limb boiling.	h m s 5 11 36.6 Good.	h m s 5 11 35.9 Lost sight of near limb.	h m s 5 11 35.2 Good.
60	9.5	D	5 18 11 A guess.	...	...	...
38	10-11	R	5 21 15.2 Very good.	5 21 21.9 Good.	...	5 21 15.2 Good.
40	10-11	R	5 27 56.7	5 27 58.0 Very faint.	...	...
65	9.5	D	Star not seen.	Star not seen.	No star seen within five minutes of time.	Star not seen.
42	10-11	R	5 38 58.4	5 39 7.2 Good.	Not seen till clear of limb.	5 39 0.8 Very rough.
46	9.5	R	5 52 24.2	5 52 20.9 Faint; slightly within limb when seen.	Not seen till clear of limb.	5 52 25.2
51	11	R	...	...	...	...
76	8	D	Star lost near limb.	Could not follow to limb.	Moon's limb too bright.	Limb boiling too much.
98	1	D	...	...	...	...

Observations of the Total Eclipse of the Moon, 1891, November 15, made at Edinburgh. By Ralph Copeland, Ph.D.

At the Royal Observatory, Calton Hill, the sole result that could be secured was the immersion of the 11 mag. star No. 59 of Dr. Döllén's list, which disappeared suddenly at $11^{\text{h}} 44^{\text{m}} 13^{\text{s}}.2$, Greenwich mean time. Observer, Mr. Thomas Heath, with the 24-inch reflector and a power of 138.

At Blackford Hill, on the site of the new observatory, I followed the eclipse with an achromatic eye-piece, magnifying sixty-four times on the 12-inch Browning reflector. During the whole of the eclipse the clouds were very troublesome, but most of all during the total phase; hence not a single one out of twenty-one predicted occultation phenomena was visible. The beginning of the eclipse was also completely hidden; but about a quarter of an hour later the clouds broke somewhat, so that a number of ingresses of craters were recorded, as were also the beginning and end of totality, together with a few egresses of lunar features. With the power used the shading of the margin of the shadow deepened quite gradually, until within about the width of *Tycho* ($40''$) of the full shadow; thence it rapidly increased in density. The inner (darker) border of this inner shading was considered as marking the edge of the true shadow.

Greenwich
Mean Time.
h m s

10	53	0	Plato, ingress of 1st edge.
10	54	0	Plato, ingress of 2nd edge.
11	3	57	Manilius, ingress of 1st edge.
11	4	23	Manilius, ingress of 2nd edge.
11	7	8	Menelaus, ingress of centre.
11	10	9	Plinius, ingress of centre.
11	12	33	Tycho, ingress of 1st edge.
11	36	17	The shadow had apparently reached the Moon's limb; the disc, however, seemed suddenly to light up again as if the total phase had not actually commenced.
11	37	47	Moon certainly completely within the shadow.
13	0	0	Clear for a short time. Moon of a beautiful orange-copper colour. All the chief markings distinctly visible.
13	0	56	End of total phase.
13	2	44	Grimaldi, egress of 1st edge.
13	3	29	Grimaldi, egress of 2nd edge.
13	13	0	Moon clear for a moment. The markings within the shadow almost altogether invisible. Shadow of a steel-grey tint.
13	18	16	Tycho, egress of 1st edge.
13	20	12	Tycho, egress of 2nd edge.
13	23	21	Copernicus, egress of centre.
13	23	58	Copernicus, egress of 2nd edge.

All the later phenomena were hidden by the clouds, which, however, cleared off for a few hours just after the end of the eclipse.

Observations of Occultations of Stars by the Moon and of Phenomena of Jupiter's Satellites, made at the Royal Observatory, Greenwich, in the year 1891.

(Communicated by the Astronomer Royal.)

Occultations of Stars by the Moon.

Day.	Phenomena.	Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m s	Observer.
1891 Jan. 4	Reapp. 2 Libræ	Altaz.	100	Dark	18 25 54 ^a 11	J. P.
Feb. 12 (a)	Disapp. 33 Ceti	"	100	"	7 36 35 ^b 59	H.
17	" 121 Tauri	Corbett Equat.	110	"	7 2 22 ^c 75	A. M.
Mar. 2 (b)	Reapp. BAC 5395	Altaz.	100	"	14 9 31 ^b 00	W. R.
26	" 1 ² Virginis	"	100	"	11 11 22 ^b 16	W. R.
28	" 1 ¹ Libræ	"	100	"	12 13 22 ^b 40	W. R.
Apr. 18	Disapp. 42 Leonis	E. Equat.	150	"	10 33 59 ^b 40	T.
18 (c)	" 42 Leonis	Altaz.	100	"	10 33 59 ^b 46	L.
20	Reapp. 1 ¹ Virginis	E. Equat.	55	"	7 19 30 ^b 63	L.
Aug. 14	Disapp. 26 Ophiuchi	Altaz.	100	"	8 29 35 ^b 65	A. C.
Sept. 22 (d)	Reapp. 53 Tauri	"	100	"	11 0 0 ^b 30	H.
Oct. 15	Disapp. 30 Piscium	"	100	"	5 51 12 ^b 18	A. C.

Notes.

- (a) Not a good observation; the star frequently disappeared behind clouds previous to final disappearance.
 (b) Star very faint; moon low.
 (c) Star very faint.
 (d) This observation may possibly be late. At 10^h 59^m 45^s it was thought that a star was seen for a moment.

Phenomena of Jupiter's Satellites.

Day.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1891 June 16 (a)	III.	Tr. Ing. First contact	Altaz.	100	13 28 50	13 29	W. R.
16	III.	Last seen	"	"	13 38 4		"
July 6	II.	Tr. Egr. First seen	E. Equat.	150	13 43 54	13 45	H.
6	II.	Bisection	"	"	13 45 48		"
6	II.	Last contact	"	"	13 49 33		"
6	I.	Tr. Ing. First contact	"	"	13 44 24		"
6	I.	Bisection	"	"	13 46 58	13 48	"
6	I.	Last seen	"	"	13 49 41		"
13	II.	Tr. Ing. First contact	"	"	13 21 11		A. C.
13	II.	Bisection	"	"	13 22 23	13 21	"
13	II.	Last seen	"	"	13 24 33		"
22 (b)	III.	Tr. Egr. Bisection	Altaz.	100	11 25 4	11 25	H. T.
22	III.	Last contact	"	"	11 27 54		"
22 (c)	II.	Occ. R. First seen	E. Equat.	150	13 18 49		"
22	II.	Bisection	"	"	13 20 49	13 21	"
22	II.	Last contact	"	"	13 22 34		"
29	II.	Ecl. D. Last seen	Altaz.	100	11 4 48	11 5 23	H. F.
Aug. 6	I.	Ecl. D. Last seen	E. Equat.	150	11 52 32	11 52 12	A. M.
14	I.	Tr. Ing. First contact	"	"	11 30 50	11 33	C. D.
14	I.	Last seen	"	"	11 34 49		"

Day.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1891 Aug. 14	II.	Tr. Ing. First contact	E. Equat.	150	11 56 50	11 58	C. D.
14	II.	Bisection	"	"	11 58 25		"
14	II.	Last seen	"	"	12 2 9		"
15	I.	Oec. R. First seen	"	"	11 2 37		H.
15	I.	Bisection	"	"	11 4 14		"
15	I.	Last contact	"	"	11 6 24		"
30	II.	Ecl. D. Last seen	"	"	10 43 9	10 42 4	L.
30 (d)	I.	Tr. Egr. First seen	"	"	11 37 5	11 44	"
30	I.	Last contact	"	"	11 43 29		"
Sept. 10	III.	Tr. Ing. First contact	Altaz.	100	7 29 34	7 31	T.
10	III.	Last seen	"	"	7 36 18		"
10	III.	Tr. Egr. Bisection	E. Equat.	220	10 47 28	10 51	H.
10	III.	Last contact	"	"	10 53 2		"
15 (z)	I.	Tr. Ing. First contact	Altaz.	100	7 17 31	7 18	L.
15	I.	Tr. Egr. First seen	"	"	9 32 59	9 36	"
15	I.	Last contact	"	"	9 37 33		"
15	II.	Tr. Ing. First contact	"	"	10 5 44		"
15	II.	Bisection	"	"	10 8 33		"
15	II.	Last seen	"	"	10 12 3	10 13	"
15	II.	First contact	E. Equat.	220	10 9 58		A. C.
15	II.	Bisection	"	"	10 11 44		"
15	II.	Last seen	"	"	10 13 31		"

Day.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1891 Sept. 22	I.	Tr. Ing. First contact	Altaz.	100	8 58 34		H.
22	I.	Bisection	"	"	9 0 13	9 2	"
22	I.	Last seen	"	"	9 2 53		"
22	I.	Tr. Egr. First seen	E. Equat.	220	11 16 12		T.
22	I.	Last contact	"	"	11 19 27		"
22	I.	First seen	Altaz.	100	11 16 46	11 20	H.
22	I.	Bisection	"	"	11 19 21		"
22	I.	Last contact	"	"	11 22 30		"
23	I.	Ecl. R. First seen	"	"	9 3 51		L.
23	I.	First seen	E. Equat.	220	9 3 21	9 2 37	A. C.
23 (f)	I.	Full brightness	"	"	9 4 41		"
28	IV.	Ecl. D. Last seen	"	150	7 59 36	8 6 53	H.
28	III.	Ecl. R. First seen	"	"	9 17 24	9 20 7	"
28	III.	Full brightness	"	"	9 18 45		"
28 (g)	IV.	Ecl. R. First seen	"	"	11 45 56	11 48 19	"
28	IV.	Full brightness	"	"	11 55 0		"
28	I.	Occ. D. First contact	Altaz.	100	13 33 52	13 38	C. M.
28	I.	Last seen	"	"	13 36 26		"
Oct. 9	I.	Ecl. R. First seen	E. Equat.	150	7 22 24	7 22 12	A. C.
9	I.	Full brightness	"	"	7 24 29		"

Day.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1891 Oct. 12	III.	Occ. D. First contact	E. Equat.	220	10 26 47		H.
12	III.	Bisection	"	"	10 30 2		"
12	III.	Last seen	"	"	10 34 11		"
12	III.	First contact	Altaz.	100	10 27 45	10 30	H. F.
12	III.	Bisection	"	"	10 29 40		"
12	III.	Last seen	"	"	10 32 4		"
14 (h)	I.	Occ. D. Last seen	"	"	11 37 59	11 38	H.
15 (k)	IV.	Ecl. R. First seen	"	"	5 59 13	5 58 52	A. C.
15	IV.	Full brightness	"	"	6 4 43		"
15	I.	Tr. Ing. First contact	E. Equat.	55	8 45 57		"
15	I.	Bisection	"	"	8 46 52	8 46	"
15	I.	Last seen	"	"	8 49 9		"
15	I.	Tr. Egr. First seen	"	"	11 4 35		"
15	I.	Bisection	"	"	11 5 42	11 4	"
15	I.	Last contact	"	"	11 7 46		"
16 (l)	I.	Ecl. R. First seen	"	"	9 17 51	9 17 43	L.
16	I.	Full brightness	"	"	9 21 18		"
17	II.	Tr. Ing. First contact	"	220	8 36 58	8 39	T.
17	II.	Last seen	"	"	8 41 27		"
17	II.	Tr. Egr. First seen	"	"	11 29 56	11 32	"
17	II.	Last contact	"	"	11 34 10		"
23 (m)	IV.	Tr. Egr. Last contact	"	55	7 9 2	7 7	C. D.

Jan, 1892.

Phenomena of Jupiter's Satellites etc.

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Day.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1891 Oct. 23	I.	Occ. D. First contact	F. Equat.	220	7 51 1		C. D.
23	I.	Bisection	"	"	7 52 27	7 53	"
23	I.	Last seen	"	"	7 54 15		"
Nov. 2 (n)	II.	Occ. D. First contact	"	220	7 30 11		L.
2	II.	Bisection	"	"	7 34 17	7 39	"
2	II.	Last seen	"	"	7 39 9		"
7	I.	Tr. Ing. First contact	"	"	8 39 23		H.
7	I.	Bisection	"	"	8 42 8	8 42	"
7	I.	Last seen	"	"	8 45 57		"
7	I.	Tr. Egr. First seen	"	"	10 58 25		"
7	I.	Bisection	"	"	11 0 35	11 1	"
7	I.	Last contact	"	"	11 3 0		"
8	I.	Occ. D. First contact	"	"	5 58 47		A. C.
8	I.	Bisection	"	"	6 0 11	6 2	"
8	I.	Last seen	"	"	6 2 8		"
11	II.	Tr. Egr. First seen	"	"	8 5 24	8 8	H.
11	II.	Bisection	"	"	8 8 9		"
Dec. 2	I.	Tr. Egr. Last contact	"	"	5 42 40		L.
2	I.	First seen	Altaz.	100	5 37 58	5 39	A. C.
2	I.	Last contact	"	"	5 43 55		"
4	II.	Occ. D. First contact	E. Equat.	150	7 2 44		"
4	II.	Bisection	"	"	7 3 54	7 7	"
4	II.	Last seen	"	"	7 6 56		"

Day.	Satellite.	Phenomenon.	Telescope.	wer.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1891 Dec. 5 (o)	III.	Tr. Egr. First seen	E. Equat.	230	6 18.2		H.
5	III.	Bisection	"	"	6 20 47		"
5	III.	Last contact	"	"	6 25 46	6 21	"
5 (p)	III.	Bisection	Photo. Equat.	225	6 19 38		C. D.
5	III.	Last contact	"	"	6 21 58		"
9	I.	Tr. Ing. First contact	E. Equat.	150	5 15 22	5 17	H.
9	I.	Last seen	"	"	5 19 47		"
17	I.	Ecl. R. First seen	Altaz.	100	8 9.59	8 9 26	H.
17	I.	Full brightness	"	"	8 11 54		"

Notes.

- (a) Satellite very faint. (b) The phenomenon occurred so much earlier than was expected that the first contact was lost. *Jupiter* was examined at about 11^h 18^m, and a point of light was suspected at the place where III. was ultimately seen, but the appearance was intermittent, and very like scintillations at other points of the limb. The attention of the observer was then called away till 11^h 25^m.
- (c) Cloudy at times, but quite clear at first and last contacts. (d) A good observation. Limb very steady and well defined.
- (e) A rough observation; *Jupiter* clouded. Last contact not seen; cloudy. (f) Rather uncertain.
- (g) The satellite reappeared almost coincident with III.; the time may be late on this account. (h) Near I.; the time may be late on this account.
- (i) *Jupiter* in light cloud; satellite hardly visible; observation not considered good. (k) Satellite very faint indeed; observation not worth much.
- (l) A very good observation. (m) Satellite very faint indeed; observation not worth much.
- (n) Observation not good; cloudy. The bisection probably the best observation, as *Jupiter* was bright for some 30^s about that time.
- (o) Not a good observation; windy; definition bad. (p) Very unsteady; windy.

The aperture of the object glass of the East Equatoreal is 6.7 inches, of the Corbett 6.5 inches, and of the Altaz. 3 $\frac{3}{4}$ inches. The abbreviation "Photo. Equat." denotes the guiding telescope of the Photographic Equatoreal, aperture 10 inches.

The initials H. T., T., L., H., A. C., J. P., W. R., H. F., A. M., C. M., C. D., are those of Mr. Turner, Mr. Thackeray, Mr. Lewis, Mr. Hollis, Mr. Crommelin, Mr. Power, Mr. Russell, Mr. Furner, Mr. Miskin, Mr. Martin, and Mr. Davidson respectively.

Ephemeris of Juno near the time of Opposition, 1891; computed from the Corrected Elements published in "Monthly Notices," vol. l., p. 495.

(Communicated by the Superintendent of the "Nautical Almanac.")

At Transit at Greenwich.

Month and Day.	Apparent Right Ascension.			Apparent Declination.	Month and Day.	Apparent Right Ascension.			Apparent Declination.
	h	m	s	S. ° ' " "		h	m	s	S. ° ' " "
July 23	21	55	1'85	S. 1° 10' 23"9	Aug. 22	21	33	31'06	S. 4° 50' 15"5
24	21	54	31'26	1 14 46'5	23	21	32	42'66	4 59 59'7
25	21	53	59'44	1 19 22'7	24	21	31	54'54	5 9 48'8
26	21	53	26'43	1 24 12'5	25	21	31	6'76	5 19 42'3
27	21	52	52'25	1 29 15'8	26	21	30	19'40	5 29 39'8
28	21	52	16'94	1 34 32'7	27	21	29	32'51	5 39 40'7
29	21	51	40'51	1 40 3'0	28	21	28	46'16	5 49 44'6
30	21	51	2'99	1 45 46'6	29	21	28	0'41	5 59 50'8
31	21	50	24'43	1 51 43'6	30	21	27	15'32	6 9 58'9
Aug. 1	21	49	44'86	1 57 53'7	31	21	26	30'97	6 20 8'2
2	21	49	4'34	2 4 16'7	Sept. 1	21	25	47'41	6 30 18'2
3	21	48	22'91	2 10 52'5	2	21	25	4'70	6 40 28'5
4	21	47	40'59	2 17 41'0	3	21	24	22'90	6 50 38'6
5	21	46	57'45	2 24 41'9	4	21	23	42'10	7 0 47'7
6	21	46	13'54	2 31 54'7	5	21	23	2'31	7 10 55'5
7	21	45	28'90	2 39 19'5	6	21	22	23'60	7 21 1'3
8	21	44	43'59	2 46 55'8	7	21	21	46'03	7 31 4'8
9	21	43	57'66	2 54 43'3	8	21	21	9'66	7 41 5'5
10	21	43	11'18	3 2 41'8	9	21	20	34'51	7 51 2'9
11	21	42	24'19	3 10 50'9	10	21	20	0'65	8 0 56'5
12	21	41	36'76	3 19 10'2	11	21	19	28'11	8 10 45'8
13	21	40	48'94	3 27 39'3	12	21	18	56'94	8 20 30'5
14	21	40	0'79	3 36 17'9	13	21	18	27'17	8 30 10'2
15	21	39	12'37	3 45 5'4	14	21	17	58'83	8 39 44'3
16	21	38	23'75	3 54 1'6	15	21	17	31'97	8 49 12'6
17	21	37	34'99	4 3 6'1	16	21	17	6'62	8 58 34'8
18	21	36	46'15	4 12 18'3	17	21	16	42'80	9 7 50'5
19	21	35	57'26	4 21 37'8	18	21	16	20'53	9 16 59'4
20	21	35	8'42	4 31 4'2	19	21	15	59'85	9 26 1'1
21	21	34	19'66	S. 4° 40' 36'9	20	21	15	40'76	S. 9° 34' 55'4

Month and Day.	Apparent Right Ascension.			Apparent Declination.	Month and Day.	Apparent Right Ascension.			Apparent Declination.
	h	m	s			h	m	s	
Sept. 21	21	15	23.30	S. 9° 43' 42" 0	Oct. 20	21	19	32.05	S. 12° 47' 38" 8
22	21	15	7.48	9 52 20.7	21	21	20	6.31	12 51 17.7
23	21	14	53.34 ¹	10 0 51.1	22	21	20	42.16	12 54 45.6
24	21	14	40.88	10 9 13.0	23	21	21	19.58	12 58 2.5
25	21	14	30.12	10 17 26.1	24	21	21	58.57	13 1 8.4
26	21	14	21.08	10 25 30.2	25	21	22	39.10	13 4 3.3
27	21	14	13.78	10 33 25.1	26	21	23	21.16	13 6 47.2
28	21	14	8.24	10 41 10.5	27	21	24	4.74	13 9 20.1
29	21	14	4.45	10 48 46.2	28	21	24	49.82	13 11 42.1
30	21	14	2.43	10 56 12.1	29	21	25	36.39	13 13 53.1
Oct. 1	21	14	2.18	11 3 28.0	30	21	26	24.42	13 15 53.2
2	21	14	3.73	11 10 33.8	31	21	27	13.90	13 17 42.4
3	21	14	7.05	11 17 29.4	Nov. 1	21	28	4.81	13 19 20.9
4	21	14	12.17	11 24 14.4	2	21	28	57.13	13 20 48.4
5	21	14	19.08	11 30 49.0	3	21	29	50.84	13 22 5.4
6	21	14	27.76	11 37 13.0	4	21	30	45.92	13 23 11.5
7	21	14	38.24	11 43 26.1	5	21	31	42.35	13 24 7.2
8	21	14	50.49	11 49 28.6	6	21	32	40.12	13 24 52.2
9	21	15	4.50	11 55 20.1	7	21	33	39.19	13 25 26.9
10	21	15	20.28	12 1 0.6	8	21	34	39.56	13 25 51.2
11	21	15	37.81	12 6 30.1	9	21	35	41.18	13 26 5.0
12	21	15	57.07	12 11 48.7	10	21	36	44.06	13 26 8.5
13	21	16	18.06	12 16 56.2	11	21	37	48.15	13 26 1.8
14	21	16	40.76	12 21 52.7	12	21	38	53.44	13 25 45.0
15	21	17	5.16	12 26 38.2	13	21	39	59.91	13 25 18.0
16	21	17	31.24	12 31 12.4	14	21	41	7.55	13 24 41.2
17	21	17	58.98	12 35 35.6	15	21	42	16.32	13 23 54.4
18	21	18	28.37	12 39 47.7	16	21	43	26.21	S. 13 22 57.7
19	21	18	59.40	S. 12 43 48.8					

"Nautical Almanac" Office,
3 Verulam Buildings, Gray's Inn, W.C.:
1892 January 8.

Ephemerides of the Satellites of Saturn, 1891-92. By A. Marth.

(Continued.)

The following are continuations of the Tables explained on pp. 566, ff. of vol. li. :—

Greenwich Noon.	P	L	Diff.	B	B	A-L	Long. of 1/2's Central Mer.
1892. Mar. 2	355°832	179°086	131	+ 2°451	+ 1°926	- 1°543	94°36
4	°819	178°955	133	2°378	1°956	1°351	342°12
6	°806	178°822	135	2°304	1°987	1°157	229°88
8	°793	178°687	137	2°230	2°017	0°961	117°63
10	°779	178°550	137	2°155	2°047	0°764	5°38
12	355°766	178°413	138	+ 2°080	+ 2°078	- 0°566	253°13
14	°752	178°275	139	2°005	2°108	- 0°367	140°87
16	°739	178°136	139	1°930	2°139	- 0°168	28°61
18	°725	177°997	139	1°855	2°169	+ 0°032	276°35
20	°711	177°858	139	1°781	2°199	+ 0°231	164°08
22	355°698	177°719	138	+ 1°707	+ 2°230	+ 0°430	51°81
24	°684	177°581	137	1°634	2°260	0°629	299°53
26	°671	177°444	135	1°561	2°290	0°827	187°25
28	°658	177°309	134	1°490	2°321	1°023	74°96
30	°645	177°175	133	1°420	2°351	1°218	322°67
Apr. 1	355°632	177°042	130	+ 1°352	+ 2°381	+ 1°411	210°37
3	°619	176°912	127	1°285	2°412	1°601	98°06
5	°607	176°785	125	1°220	2°442	1°789	345°74
7	°595	176°660	122	1°156	2°472	1°975	233°42
9	°583	176°538	118	1°094	2°503	2°157	121°09
11	355°571	176°420	115	+ 1°035	+ 2°533	+ 2°336	8°75
13	°560	176°305	112	0°977	2°563	2°512	256°41
15	°549	176°193	108	0°922	2°594	2°684	144°06
17	°539	176°085	103	0°869	2°624	2°852	31°70
19	°529	175°982	99	0°819	2°654	3°017	279°33
21	355°520	175°883	95	+ 0°771	+ 2°684	+ 3°177	166°95
23	°511	°788	91	0°726	2°715	3°332	54°57
25	°502	°697	85	0°683	2°745	3°483	302°18
27	°494	°612	80	0°643	2°775	3°629	189°78
29	°486	°532	75	0°606	2°805	3°770	77°37

Greenwich Noon.		P	L	Diff.	B	B	A-L	Long. of h's Central Mer.
1892.								
May	1	355°479	175°457	70	+ 0°573	+ 2°836	+ 3°905	324°96
	3	'472	'387	65	0°542	2°866	4°036	212°54
	5	'466	'322	59	0°514	2°896	4°161	100°11
	7	'461	'263	53	0°490	2°926	4°280	347°67
	9	'456	'210	48	0°468	2°956	4°394	235°22
	11	355°451	175°162	42	+ 0°450	+ 2°986	+ 4°502	122°76
	13	'447	'120	36	0°435	3°017	4°604	10°30
	15	'444	'084	30	0°423	3°047	4°701	257°83
	17	'441	'054	24	0°414	3°077	4°792	145°35
	19	'439	'030	19	0°408	3°107	4°877	32°86
	21	355°437	175°011	12	+ 0°406	+ 3°137	+ 4°956	280°37
	23	'436	174°999	6	0°407	3°167	5°029	167°87
	25	'435	174°993	0	0°411	3°198	5°095	55°37
	27	'435	174°993	5	0°419	3°228	5°156	302°85
	29	'436	174°998	12	0°430	3°258	5°211	190°33
	31	355°437	175°010	18	+ 0°444	+ 3°288	+ 5°260	77°80
June	2	'439	'028	24	0°461	3°318	5°302	325°27
	4	'441	'052	30	0°482	3°348	5°338	212°73
	6	'444	'082	36	0°505	3°378	5°369	100°18
	8	'447	'118	41	0°542	3°408	5°394	347°62
	10	355°451	175°159	47	+ 0°562	+ 3°438	+ 5°413	235°06
	12	'456	'206	54	0°595	3°468	5°426	122°50
	14	'461	'260	59	0°631	3°498	5°433	9°93
	16	'467	'319	64	0°670	3°529	5°434	257°35
	18	'473	'383	70	0°712	3°559	5°430	144°77
	20	355°480	175°453	76	+ 0°757	+ 3°589	+ 5°420	32°18
	22	'487	'529	81	0°804	3°619	5°405	279°59
	24	'495	'610	87	0°854	3°649	5°384	166°99
July	26	'503	'697	92	0°907	3°679	5°358	54°39
	28	'512	'789	97	0°963	3°709	5°326	301°79
	30	345°521	175°886	103	+ 1°022	+ 3°739	+ 5°289	189°18
	2	'531	175°989	108	1°083	3°769	5°247	76°56
	4	'541	176°097	112	1°147	3°799	5°200	323°94
	6	'552	176°209	117	1°213	3°829	5°148	211°32
	8	'564	176°326	122	1°282	3°859	5°091	98°70
	10	355°576	176°448	127	+ 1°353	+ 3°889	+ 5°029	346°07
	12	'588	176°575	131	1°426	3°918	4°963	233°44
	14	'601	176°706	136	1°501	3°948	4°892	120°81

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Greenwich Noon.	P	L	Diff.	B	B	$\Delta-L$	Long. of Mer.
1892. July 16	°614	176°842	140	1°579	3°978	4°817	8°17
18	°627	176°982	145	1°659	4°008	4°737	255°53
20	355°641	177°127	148	+1°741	+4°038	+4°653	142°89
22	°656	177°275	153	1°825	4°068	4°565	30°25
24	°671	177°428	157	1°910	4°098	4°472	277°60
26	°686	177°585	160	1°998	4°128	4°376	164°95
28	°702	177°745	164	2°087	4°158	4°276	52°30
30	355°718	177°909	168	+2°178	+4°188	+4°172	299°65
Aug. 1	°734	178°077	171	2°271	4°218	4°065	187°00
3	°751	178°248	175	2°366	4°248	3°954	74°35
5	°768	178°423	178	2°462	4°277	3°840	321°70
7	°785	178°601	181	2°559	4°307	3°723	209°04
9	355°803	178°782		+2°658	+4°337	+3°602	96°39

The difference of successive values of the longitude of *Saturn's* central meridian (corrected for phase) in the last column varies between 1687°77 and 1687°34.

Greenwich Noon.	Semidiameter of Ball.			Semifaxis of Ring.		<i>Mimas.</i>			Diff.
	Equat.	Phase.	Polar.	Major.	Minor.	α_1	δ_1	l_1-L	
1892. Mar. 2	9°56	0°003	8°63	22°05	0°94	30°13	+1°29	326°17	764°16
4	9°57	°003	8°64	22°07	0°92	30°16	1°25	10°33	°15
6	9°58	°002	8°64	22°09	0°89	30°18	1°21	54°48	°15
8	9°59	°002	8°65	22°11	0°86	30°20	1°17	98°63	°15
10	9°60	°001	8°66	22°12	0°83	30°22	1°14	142°78	°15
12	9°60	...	8°66	22°12	0°80	30°23	+1°10	186°93	°15
14	9°60	...	8°66	22°13	0°77	30°24	1°06	231°08	°15
16	9°60	...	8°66	22°13	0°74	30°24	1°02	275°23	°14
18	9°60	...	8°66	22°13	0°72	30°24	0°98	319°37	°14
20	9°60	..	8°66	22°13	0°69	30°23	0°94	3°51	°13
22	9°60	...	8°66	22°12	0°66	30°22	+0°90	47°64	764°14
24	9°59	...	8°65	22°11	0°63	30°21	0°86	91°78	°13
26	0°58	°001	8°65	22°09	0°60	30°19	0°82	135°91	°12
28	9°58	°001	8°64	22°08	0°57	30°17	0°78	180°03	°12
30	9°57	°002	8°63	22°06	0°55	30°14	0°75	224°15	°12
Apr. 1	9°56	°002	8°62	22°03	0°52	30°11	+0°71	268°27	°11
3	9°55	°004	8°61	22°01	0°49	30°07	0°67	312°38	°11
5	9°53	°005	8°60	21°98	0°47	30°03	0°64	356°49	°10
7	9°52	°006	8°59	21°95	0°44	29°99	0°60	40°59	°10

Greenwich Noon.	Semidiameter of Ball.			Semiaxis of Ring.		a_1	<i>Mimas.</i> b_1	$i_1 - L$	Diff.
	Equat.	Phase.	Polar.	Major.	Minor.				
1892.									
Apr. 9	9 ^h 51	007	8 ^h 57	21 ^h 91	0 ^h 42	29 ^h 94	0 ^h 57	84 ^h 69	09
11	9 ^h 49	008	8 ^h 56	21 ^h 87	0 ^h 40	29 ^h 89	+0 ^h 54	128 ^h 78	764 ^h 08
13	9 ^h 47	009	8 ^h 54	21 ^h 83	0 ^h 37	29 ^h 84	0 ^h 51	172 ^h 86	08
15	9 ^h 45	010	8 ^h 53	21 ^h 79	0 ^h 35	29 ^h 78	0 ^h 48	216 ^h 94	07
17	9 ^h 43	012	8 ^h 51	21 ^h 75	0 ^h 33	29 ^h 72	0 ^h 45	261 ^h 01	07
19	9 ^h 41	013	8 ^h 49	21 ^h 70	0 ^h 31	29 ^h 65	0 ^h 42	305 ^h 08	06
21	9 ^h 39	014	8 ^h 47	21 ^h 65	0 ^h 29	29 ^h 58	+0 ^h 40	349 ^h 14	06
23	9 ^h 37	015	8 ^h 45	21 ^h 60	0 ^h 27	29 ^h 51	0 ^h 37	33 ^h 20	05
25	9 ^h 34	017	8 ^h 43	21 ^h 54	0 ^h 26	29 ^h 44	0 ^h 35	77 ^h 25	04
27	9 ^h 32	019	8 ^h 41	21 ^h 49	0 ^h 24	29 ^h 36	0 ^h 33	121 ^h 29	03
29	9 ^h 29	020	8 ^h 39	21 ^h 43	0 ^h 23	29 ^h 28	0 ^h 31	165 ^h 32	03
May 1	9 ^h 27	022	8 ^h 36	21 ^h 37	0 ^h 21	29 ^h 20	+0 ^h 29	209 ^h 35	764 ^h 02
3	9 ^h 24	023	8 ^h 34	21 ^h 31	0 ^h 20	29 ^h 12	0 ^h 28	253 ^h 37	01
5	9 ^h 22	024	8 ^h 31	21 ^h 25	0 ^h 19	29 ^h 03	0 ^h 26	297 ^h 38	00
7	9 ^h 19	026	8 ^h 29	21 ^h 18	0 ^h 18	28 ^h 95	0 ^h 25	341 ^h 38	764 ^h 00
9	9 ^h 16	027	8 ^h 26	21 ^h 12	0 ^h 17	28 ^h 86	0 ^h 24	25 ^h 38	763 ^h 99
11	9 ^h 13	028	8 ^h 24	21 ^h 05	0 ^h 17	28 ^h 77	+0 ^h 23	69 ^h 37	99
13	9 ^h 10	029	8 ^h 21	20 ^h 99	0 ^h 16	28 ^h 68	0 ^h 22	113 ^h 36	98
15	9 ^h 07	031	8 ^h 19	20 ^h 92	0 ^h 15	28 ^h 59	0 ^h 21	157 ^h 34	97
17	9 ^h 04	032	8 ^h 16	20 ^h 85	0 ^h 15	28 ^h 49	0 ^h 21	201 ^h 31	96
19	9 ^h 01	033	8 ^h 13	20 ^h 78	0 ^h 15	28 ^h 40	0 ^h 20	245 ^h 27	95
21	8 ^h 98	034	8 ^h 10	20 ^h 71	0 ^h 15	28 ^h 30	+0 ^h 20	289 ^h 22	763 ^h 95
23	8 ^h 95	034	8 ^h 08	20 ^h 64	0 ^h 15	28 ^h 20	0 ^h 20	333 ^h 17	95
25	8 ^h 92	035	8 ^h 05	20 ^h 57	0 ^h 15	28 ^h 11	0 ^h 20	17 ^h 12	93
27	8 ^h 89	036	8 ^h 02	20 ^h 50	0 ^h 15	28 ^h 01	0 ^h 20	61 ^h 05	93
29	8 ^h 86	037	7 ^h 99	20 ^h 43	0 ^h 15	27 ^h 91	0 ^h 21	104 ^h 98	92
31	8 ^h 83	037	7 ^h 96	20 ^h 36	0 ^h 16	27 ^h 81	+0 ^h 22	148 ^h 90	92
June 2	8 ^h 80	038	7 ^h 94	20 ^h 28	0 ^h 16	27 ^h 72	0 ^h 22	192 ^h 82	91
4	8 ^h 77	038	7 ^h 91	20 ^h 21	0 ^h 17	27 ^h 62	0 ^h 23	236 ^h 73	90
6	8 ^h 74	038	7 ^h 88	20 ^h 14	0 ^h 18	27 ^h 52	0 ^h 24	280 ^h 63	90
8	8 ^h 71	038	7 ^h 85	20 ^h 07	0 ^h 19	27 ^h 42	0 ^h 25	324 ^h 53	89
10	8 ^h 68	039	7 ^h 83	20 ^h 00	0 ^h 20	27 ^h 33	+0 ^h 27	8 ^h 42	763 ^h 88
12	8 ^h 64	039	7 ^h 80	19 ^h 93	0 ^h 21	27 ^h 23	0 ^h 28	52 ^h 30	88
14	8 ^h 61	039	7 ^h 77	19 ^h 86	0 ^h 22	27 ^h 14	0 ^h 30	96 ^h 18	87
16	8 ^h 58	039	7 ^h 74	19 ^h 79	0 ^h 23	27 ^h 04	0 ^h 32	140 ^h 05	87
18	8 ^h 55	038	7 ^h 72	19 ^h 72	0 ^h 24	26 ^h 95	0 ^h 34	183 ^h 92	86
20	8 ^h 52	038	7 ^h 69	19 ^h 65	0 ^h 26	26 ^h 85	+0 ^h 36	227 ^h 78	86
22	8 ^h 50	038	7 ^h 66	19 ^h 58	0 ^h 27	26 ^h 76	0 ^h 38	271 ^h 64	85

Greenwich Noon.	Semidiameter of Ball.			Semiaxis of Ring.		Mimas.			
	Equat.	Phase.	Polar.	Major.	Minor.	a_1	b_1	$l_1 - L$	Diff.
1892.									
June 24	8 ^h 47	037	7 ^h 64	19 ^h 52	0 ^h 29	26 ^h 67	0 ^h 40	315 ^o 49	0 ^o
26	8 ^h 44	037	7 ^h 61	19 ^h 45	0 ^h 31	26 ^h 58	0 ^h 42	359 ^o 34	.85
28	8 ^h 41	036	7 ^h 59	19 ^h 38	0 ^h 33	26 ^h 49	0 ^h 45	43 ^o 18	.84
30	8 ^h 38	036	7 ^h 56	19 ^h 32	0 ^h 34	26 ^h 40	+0 ^h 47	87 ^o 01	.83
July 2	8 ^h 35	035	7 ^h 54	19 ^h 26	0 ^h 36	26 ^h 31	0 ^h 50	130 ^o 84	763 ^o 83
4	8 ^h 33	034	7 ^h 51	19 ^h 19	0 ^h 38	26 ^h 23	0 ^h 53	174 ^o 67	.83
6	8 ^h 30	034	7 ^h 49	19 ^h 13	0 ^h 40	26 ^h 14	0 ^h 55	218 ^o 50	.83
8	8 ^h 27	033	7 ^h 46	19 ^h 07	0 ^h 43	26 ^h 06	0 ^h 58	262 ^o 32	.82
10	8 ^h 25	032	7 ^h 44	19 ^h 01	0 ^h 45	25 ^h 98	+0 ^h 61	306 ^o 13	.81
12	8 ^h 22	031	7 ^h 42	18 ^h 95	0 ^h 47	25 ^h 90	0 ^h 64	349 ^o 94	.81
14	8 ^h 20	030	7 ^h 40	18 ^h 90	0 ^h 49	25 ^h 82	0 ^h 68	33 ^o 75	.81
16	8 ^h 17	029	7 ^h 37	18 ^h 84	0 ^h 52	25 ^h 75	0 ^h 71	77 ^o 56	.80
18	8 ^h 15	029	7 ^h 35	18 ^h 79	0 ^h 54	25 ^h 67	0 ^h 74	121 ^o 36	.80
20	8 ^h 13	027	7 ^h 33	18 ^h 73	0 ^h 57	25 ^h 60	+0 ^h 78	165 ^o 16	763 ^o 80
22	8 ^h 10	026	7 ^h 31	18 ^h 68	0 ^h 59	25 ^h 53	0 ^h 81	208 ^o 96	.79
24	8 ^h 08	025	7 ^h 29	18 ^h 63	0 ^h 62	25 ^h 46	0 ^h 85	252 ^o 75	.79
26	8 ^h 06	024	7 ^h 27	18 ^h 58	0 ^h 65	25 ^h 39	0 ^h 88	296 ^o 54	.78
28	8 ^h 04	022	7 ^h 25	18 ^h 53	0 ^h 67	25 ^h 33	0 ^h 92	340 ^o 32	.78
30	8 ^h 02	021	7 ^h 24	18 ^h 49	0 ^h 70	25 ^h 26	+0 ^h 96	24 ^o 11	.78
Aug. 1	8 ^h 00	020	7 ^h 22	18 ^h 44	0 ^h 73	25 ^h 20	1 ^h 00	67 ^o 89	.78
3	7 ^h 98	019	7 ^h 20	18 ^h 40	0 ^h 76	25 ^h 14	1 ^h 04	111 ^o 67	.78
5	7 ^h 96	018	7 ^h 18	18 ^h 36	0 ^h 79	25 ^h 08	1 ^h 08	155 ^o 45	.78
7	7 ^h 94	017	7 ^h 17	18 ^h 32	0 ^h 82	25 ^h 03	1 ^h 12	199 ^o 23	763 ^o 77
9	7 ^h 93	0016	7 ^h 15	18 ^h 28	0 ^h 85	24 ^h 98	+1 ^h 16	243 ^o 00	

Enceladus.

Tethys.

Greenwich Noon.	a_2	b_2	$l_2 - L$	Diff.	a_3	b_3	$l_3 - L$	Diff.
1892.								
Mar. 2	38 ^h 65	+1 ^h 65	264 ^o 01	525 ^o 60	47 ^h 85	+2 ^h 05	175 ^o 425	381 ^o 535
4	38 ^h 69	1 ^h 61	69 ^o 61	.61	47 ^h 89	1 ^h 99	196 ^o 960	.536
6	38 ^h 72	1 ^h 56	235 ^o 22	.61	47 ^h 93	1 ^h 93	218 ^o 496	.537
8	38 ^h 75	1 ^h 51	40 ^o 83	.61	47 ^h 96	1 ^h 87	240 ^o 033	.536
10	38 ^h 77	1 ^h 46	206 ^o 44	.61	47 ^h 99	1 ^h 80	261 ^o 569	.536
12	38 ^h 78	+1 ^h 41	12 ^o 05	.60	48 ^h 01	+1 ^h 74	283 ^o 105	.536
14	38 ^h 79	1 ^h 36	177 ^o 65	.60	48 ^h 02	1 ^h 68	304 ^o 641	.535
16	38 ^h 80	1 ^h 31	343 ^o 25	.60	48 ^h 03	1 ^h 62	326 ^o 176	.533
18	38 ^h 79	1 ^h 26	148 ^o 85	.60	48 ^h 02	1 ^h 55	347 ^o 709	.532
20	38 ^h 79	1 ^h 21	314 ^o 45	.60	48 ^h 01	1 ^h 49	9 ^o 241	.531
22	38 ^h 77	+1 ^h 16	120 ^o 05	525 ^o 60	48 ^h 00	+1 ^h 43	30 ^o 772	381 ^o 529

Greenwich Noon. 1892.	<i>Enceladus.</i>				<i>Tethys.</i>			
	a_2	b_2	l_2-L	Diff.	a_3	b_3	l_3-L	Diff.
Mar. 24	38° 75	1° 11	285° 65	°	47° 97	1° 37	52° 301	°
26	38° 73	1° 06	91° 24	° 59	47° 94	1° 31	73° 827	° 526
28	38° 70	1° 01	256° 83	° 59	47° 90	1° 25	95° 350	° 523
30	38° 66	0° 96	62° 42	° 59	47° 86	1° 19	116° 871	° 521
Apr. 1	38° 62	+0° 91	228° 00	° 58	47° 81	+1° 13	138° 388	° 517
3	38° 58	0° 87	33° 58	° 58	47° 76	1° 07	159° 902	° 514
5	38° 53	0° 82	199° 15	° 57	47° 69	1° 01	181° 412	° 510
7	38° 47	0° 78	4° 72	° 57	47° 62	0° 96	202° 918	° 506
9	38° 41	0° 73	170° 29	° 57	47° 55	0° 91	224° 420	° 502
11	38° 34	+0° 69	335° 85	° 56	47° 47	+0° 86	245° 918	° 498
13	38° 27	0° 65	141° 40	525° 55	47° 38	0° 81	267° 411	381° 493
15	38° 20	0° 61	306° 95	° 55	47° 29	0° 76	288° 899	° 488
17	38° 12	0° 58	112° 49	° 54	47° 19	0° 71	310° 382	° 483
19	38° 04	0° 54	278° 03	° 54	47° 09	0° 67	331° 860	° 478
21	37° 95	+0° 51	83° 56	° 53	46° 98	+0° 63	353° 333	° 473
23	37° 86	0° 48	249° 09	° 53	46° 87	0° 59	14° 800	° 467
25	37° 76	0° 45	54° 61	° 52	46° 75	0° 56	36° 261	° 461
27	37° 66	0° 42	220° 13	° 52	46° 63	0° 52	57° 717	° 456
29	37° 56	0° 40	25° 64	° 51	46° 50	0° 49	79° 167	° 450
May 1	37° 46	+0° 37	191° 14	° 50	46° 37	+0° 46	100° 610	° 443
3	37° 36	0° 35	356° 64	525° 50	46° 24	0° 44	122° 047	381° 437
5	37° 25	0° 33	162° 13	° 49	46° 11	0° 41	143° 479	° 432
7	37° 14	0° 32	327° 61	° 48	45° 97	0° 39	164° 904	° 425
9	37° 02	0° 30	133° 09	° 48	45° 83	0° 37	186° 322	° 418
11	36° 91	+0° 29	298° 56	° 47	45° 69	+0° 36	207° 734	° 412
13	36° 79	0° 28	104° 02	° 46	45° 54	0° 35	229° 140	° 406
15	36° 67	0° 27	269° 47	° 45	45° 39	0° 34	250° 539	° 399
17	36° 55	0° 26	74° 92	° 45	45° 24	0° 33	271° 932	° 393
19	36° 43	0° 26	240° 36	° 44	45° 09	0° 32	293° 319	° 387
21	36° 31	+0° 26	45° 80	° 44	44° 94	+0° 32	314° 699	° 380
23	36° 18	0° 26	211° 23	525° 43	44° 79	0° 32	336° 072	381° 373
25	36° 06	0° 26	16° 65	° 42	44° 64	0° 32	357° 439	° 367
27	35° 93	0° 26	182° 07	° 42	44° 48	0° 33	18° 800	° 361
29	35° 81	0° 27	347° 48	° 41	44° 33	0° 33	40° 154	° 354
31	35° 68	+0° 28	152° 88	° 40	44° 17	+0° 34	61° 502	° 348
June 2	35° 56	0° 29	318° 28	° 40	44° 02	0° 35	82° 843	° 341
4	35° 43	0° 30	123° 67	° 39	43° 86	0° 37	104° 178	° 335
6	35° 31	0° 31	289° 05	° 38	43° 71	0° 39	125° 507	° 329
				° 38				° 323

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<i>Enceladus.</i>					<i>Tethys.</i>				
Greenwich Noon. 1892.	a_2	b_2	l_2-L	Diff.	a_3	b_3	l_3-L	Diff.	
June 8	35°18	0°33	94°43	°37	43°55	0°41	146°830	°317	
10	35°06	+0°34	259°80	525°37	43°40	+0°43	168°147	381°311	
12	34°93	0°36	65°17	°36	43°24	0°45	189°458	°306	
14	34°81	0°38	230°53	°35	43°09	0°47	210°764	°299	
16	34°69	0°41	35°88	°35	42°94	0°50	232°063	°294	
18	34°57	0°43	201°23	°35	42°79	0°53	253°357	°289	
20	34°45	+0°45	6°58	°34	42°64	+0°56	274°646	°283	
22	34°33	0°48	171°92	°33	42°50	0°60	295°929	°278	
24	34°21	0°51	337°25	°33	42°35	0°63	317°207	°272	
26	34°10	0°54	142°58	°32	42°21	0°67	338°479	°267	
28	33°98	0°57	307°90	°32	42°06	0°71	359°746	°262	
30	33°87	+0°60	113°22	525°31	41°92	+0°75	21°008	381°257	
July 2	33°76	0°64	278°53	°31	41°79	0°79	42°265	°253	
4	33°65	0°67	83°84	°30	41°65	0°83	63°518	°248	
6	33°54	0°71	249°14	°30	41°52	0°88	84°766	°244	
8	33°43	0°75	54°44	°30	41°39	0°93	106°010	°239	
10	33°33	+0°79	219°74	°29	41°26	+0°97	127°249	°235	
12	33°23	0°83	25°03	°29	41°13	1°02	148°484	°231	
14	33°13	0°87	190°32	°28	41°01	1°07	169°715	°227	
16	33°03	0°91	355°60	°28	40°89	1°13	190°942	°223	
18	32°93	0°95	160°88	°27	40°77	1°18	212°165	°220	
20	32°84	+1°00	326°15	525°28	40°65	+1°23	233°385	381°216	
22	32°75	1°04	131°43	°27	40°54	1°29	254°601	°212	
24	32°66	1°09	296°70	°27	40°43	1°35	275°813	°209	
26	32°57	1°14	101°97	°26	40°32	1°41	297°022	°206	
28	32°49	1°18	267°23	°26	40°22	1°46	318°228	°203	
30	32°41	+1°23	72°49	°26	40°12	+1°52	339°431	°200	
Aug. 1	32°33	1°28	237°75	°26	40°02	1°59	0°631	°197	
3	32°25	1°33	43°01	°25	39°93	1°65	21°828	°195	
5	32°18	1°38	208°26	°25	39°84	1°71	43°023	°192	
7	32°11	1°43	13°51	525°25	39°75	1°77	64°215	381°190	
9	32°04	+1°49	178°76		39°66	+1°84	82°405		
<i>Dione.</i>					<i>Rhea.</i>				
Greenwich Noon. 1892.	a_4	b_4	l_4-L	Diff.	a_5	b_5	l_5-L	Diff.	
Mar. 2	61°28	+2°62	17°228	263°207	85°58	+3°66	245°888	159°515	
4	61°34	2°55	280°435	°208	85°66	3°55	45°403	°517	
6	61°39	2°47	183°643	°209	85°73	3°45	204°920	°518	
8	61°43	2°39	86°852	°210	85°79	3°34	4°438	°518	

Greenwich Noon. 1892.		<i>Dione.</i>			Diff.	<i>Rhea.</i>			Diff.
		a_1	b_1	l_1-L		a_2	b_2	l_2-L	
Mar.	10	61°47'	2°31'	350°062	°	85°84'	3°23'	163°956	°
	12	61°49'	+2°23'	253°272	·210	85°87'	+3°12'	323°475	·519
	14	61°50'	2°15'	156°482	·210	85°89'	3°00'	122°995	·520
	16	61°51'	2°07'	59°691	·209	85°90'	2°39'	282°564	·519
	18	61°51'	1°99'	322°900	·209	85°89'	2°78'	82°033	·519
	20	61°49'	1°91'	226°108	·208	85°88'	2°67'	241°551	·518
	22	61°47'	+1°83'	129°314	·206	85°85'	+2°56'	41°069	·518
	24	61°44'	1°75'	32°518	263°204	85°81'	2°45'	200°585	159°516
	26	61°40'	1°67'	295°721	·203	85°75'	2°34'	0°100	·515
	28	61°35'	1°59'	198°922	·201	85°73'	2°23'	159°613	·513
	30	61°30'	1°52'	102°120	·198	85°68'	2°23'	159°613	·511
Apr.	1	61°24'	+1°44'	5°315	·195	85°61'	2°12'	319°124	·508
	3	61°16'	1°37'	268°507	·192	85°52'	+2°02'	118°632	·505
	5	61°08'	1°30'	171°696	·189	85°41'	1°92'	278°137	·502
	7	60°99'	1°23'	74°881	·185	85°30'	1°82'	77°639	·500
	9	60°89'	1°16'	338°063	·182	85°18'	1°72'	237°139	·496
	11	60°79'	+1°10'	241°240	·177	85°04'	1°62'	36°635	·492
	13	60°68'	1°03'	144°413	263°173	84°90'	+1°53'	196°127	159°488
	15	60°56'	0°97'	47°582	·169	84°74'	1°44'	355°615	·484
	17	60°44'	0°91'	310°746	·164	84°57'	1°36'	155°099	·480
	19	60°31'	0°86'	213°906	·160	84°40'	1°28'	314°579	·475
	21	60°17'	+0°81'	117°060	·154	84°22'	1°20'	114°054	·470
	23	60°02'	0°76'	20°209	·149	84°02'	+1°13'	273°524	·465
	25	59°87'	0°71'	283°352	·143	83°82'	1°06'	72°989	·461
	27	59°72'	0°67'	186°490	·138	83°61'	1°00'	232°450	·455
	29	59°56'	0°63'	89°623	·133	83°40'	0°94'	31°905	·450
May	1	59°40'	+0°59'	352°750	·127	83°18'	0°88'	191°355	·444
	3	59°23'	0°56'	255°871	263°121	82°95'	+0°83'	350°799	159°438
	5	59°05'	0°53'	158°985	·114	82°71'	0°78'	150°237	·433
	7	58°88'	0°50'	62°094	·109	82°47'	0°74'	309°670	·427
	9	58°70'	0°48'	325°197	·103	82°22'	0°70'	109°097	·421
	11	58°52'	+0°46'	228°293	·096	81°97'	0°67'	268°518	·415
	13	58°33'	0°44'	131°383	·090	81°71'	+0°64'	67°933	·409
	15	58°14'	0°43'	34°467	·084	81°45'	0°62'	227°342	·403
	17	57°95'	0°42'	297°545	·078	81°19'	0°60'	26°745	·397
	19	57°76'	0°41'	200°616	·071	80°92'	0°58'	186°142	·391
	21	57°56'	+0°41'	103°682	·066	80°65'	0°57'	345°533	·385
	23	57°37'	0°41'	6°741	263°059	80°38'	+0°57'	144°918	159°378
					·052	80°11'	0°57'	304°296	·372

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	a_s	b_s	$l_s - L$	Diff.	a_s	b_s	$l_s - L$	Diff.
May 25	57 ^h 17	0 ^m 41	269 ^o 793	0	79 ^h 84	0 ^m 57	103 ^o 668	0
27	56 ^h 97	0 ^m 42	172 ^h 839	046	79 ^h 56	0 ^m 58	263 ^h 034	366
29	56 ^h 77	0 ^m 43	75 ^h 879	040	79 ^h 28	0 ^m 59	62 ^h 394	360
31	56 ^h 57	+0 ^m 44	338 ^h 913	034	79 ^h 00	+0 ^m 61	221 ^h 747	353
June 2	56 ^h 37	0 ^m 45	241 ^h 940	027	78 ^h 73	0 ^m 63	21 ^h 094	347
4	56 ^h 18	0 ^m 47	144 ^h 962	022	78 ^h 45	0 ^m 66	180 ^h 435	341
6	55 ^h 98	0 ^m 49	47 ^h 977	015	78 ^h 17	0 ^m 69	339 ^h 771	336
8	55 ^h 78	0 ^m 52	310 ^h 986	009	77 ^h 89	0 ^m 72	139 ^h 101	330
10	55 ^h 58	+0 ^m 55	213 ^h 989	263 ^h 003	77 ^h 62	+0 ^m 76	298 ^h 424	323
12	55 ^h 39	0 ^m 58	116 ^h 986	262 ^h 997	77 ^h 35	0 ^m 80	97 ^h 742	159 ^h 318
14	55 ^h 19	0 ^m 61	19 ^h 978	992	77 ^h 07	0 ^m 85	257 ^h 053	311
16	55 ^h 00	0 ^m 64	282 ^h 964	986	76 ^h 80	0 ^m 90	56 ^h 359	306
18	54 ^h 81	0 ^m 68	185 ^h 944	980	76 ^h 54	0 ^m 95	215 ^h 659	300
20	54 ^h 62	+0 ^m 72	88 ^h 918	974	76 ^h 27	+1 ^m 01	14 ^h 954	295
22	54 ^h 43	0 ^m 76	351 ^h 887	969	76 ^h 01	1 ^m 07	174 ^h 243	289
24	54 ^h 24	0 ^m 81	254 ^h 851	964	75 ^h 75	1 ^m 13	333 ^h 527	284
26	54 ^h 06	0 ^m 86	157 ^h 809	958	75 ^h 49	1 ^m 20	132 ^h 805	278
28	53 ^h 88	0 ^m 91	60 ^h 763	954	75 ^h 24	1 ^m 27	292 ^h 078	273
30	53 ^h 70	+0 ^m 96	323 ^h 711	948	74 ^h 99	1 ^m 34	91 ^h 346	268
July 2	53 ^h 52	1 ^m 01	226 ^h 654	262 ^h 943	74 ^h 74	1 ^m 41	250 ^h 609	159 ^h 263
4	53 ^h 35	1 ^m 07	129 ^h 592	938	74 ^h 50	1 ^m 49	49 ^h 867	258
6	53 ^h 18	1 ^m 13	32 ^h 526	934	74 ^h 26	1 ^m 57	209 ^h 120	253
8	53 ^h 01	1 ^m 19	295 ^h 455	929	74 ^h 02	1 ^m 66	8 ^h 369	249
10	52 ^h 84	+1 ^m 25	198 ^h 380	925	73 ^h 79	1 ^m 74	167 ^h 613	244
12	52 ^h 68	1 ^m 31	101 ^h 300	920	73 ^h 57	1 ^m 83	326 ^h 853	240
14	52 ^h 52	1 ^m 38	4 ^h 216	916	73 ^h 35	1 ^m 92	126 ^h 088	235
16	52 ^h 37	1 ^m 44	267 ^h 128	912	73 ^h 13	2 ^m 02	285 ^h 319	231
18	52 ^h 22	1 ^m 51	170 ^h 036	908	72 ^h 92	2 ^m 11	84 ^h 546	227
20	52 ^h 07	+1 ^m 58	72 ^h 940	904	72 ^h 71	+2 ^m 21	243 ^h 769	223
22	51 ^h 92	1 ^m 65	335 ^h 840	262 ^h 900	72 ^h 51	2 ^m 31	42 ^h 987	159 ^h 218
24	51 ^h 78	1 ^m 73	238 ^h 736	896	72 ^h 31	2 ^m 41	202 ^h 202	215
26	51 ^h 64	1 ^m 80	141 ^h 629	893	72 ^h 12	2 ^m 51	1 ^h 413	211
28	51 ^h 51	1 ^m 88	44 ^h 519	890	71 ^h 94	2 ^m 62	160 ^h 621	208
30	51 ^h 38	+1 ^m 95	307 ^h 406	887	71 ^h 76	+2 ^m 73	319 ^h 826	205
Aug. 1	51 ^h 26	2 ^m 03	210 ^h 289	883	71 ^h 58	2 ^m 84	119 ^h 027	201
3	51 ^h 14	2 ^m 11	113 ^h 169	880	71 ^h 41	2 ^m 95	278 ^h 225	198
5	51 ^h 02	2 ^m 19	16 ^h 047	878	71 ^h 25	3 ^m 06	77 ^h 420	195
7	50 ^h 91	2 ^m 27	278 ^h 922	875	71 ^h 09	3 ^m 17	236 ^h 612	192
9	50 ^h 80	+2 ^m 36	181 ^h 794	262 ^h 872	70 ^h 94	+3 ^m 29	35 ^h 800	159 ^h 189

Approximate coordinates of Hyperion, referred to the axes of Saturn's Disc.

Greenwich, Noon.		x_1	y_1			x_2	y_2
1892.							
Feb.	11	-163 ^{''} 5	-11 ^{''} 0	Mar.	18	+197 ^{''} 9	-4 ^{''} 0
	12	207 ^{''} 3	8 ^{''} 5		19	156 ^{''} 3	5 ^{''} 8
	13	237 ^{''} 3	5 ^{''} 4		20	100 ^{''} 8	7 ^{''} 0
	14	252 ^{''} 2	-2 ^{''} 1		21	+37 ^{''} 4	7 ^{''} 7
	15	249 ^{''} 0	+1 ^{''} 3		22	-28 ^{''} 8	7 ^{''} 7
	16	227 ^{''} 4	4 ^{''} 6		23	93 ^{''} 2	7 ^{''} 2
	17	187 ^{''} 5	7 ^{''} 4		24	151 ^{''} 3	6 ^{''} 2
	18	131 ^{''} 0	9 ^{''} 6		25	199 ^{''} 4	4 ^{''} 9
	19	-61 ^{''} 9	10 ^{''} 7		26	234 ^{''} 5	3 ^{''} 3
	20	+13 ^{''} 8	10 ^{''} 8		27	253 ^{''} 9	-1 ^{''} 6
	21	87 ^{''} 9	9 ^{''} 6		28	255 ^{''} 7	+0 ^{''} 2
	22	152 ^{''} 7	7 ^{''} 2		29	238 ^{''} 8	1 ^{''} 8
	23	197 ^{''} 7	4 ^{''} 1		30	203 ^{''} 2	3 ^{''} 3
	24	219 ^{''} 3	+0 ^{''} 6		31	150 ^{''} 3	4 ^{''} 4
	25	216 ^{''} 9	-2 ^{''} 9	Apr.	1	83 ^{''} 5	5 ^{''} 0
	26	191 ^{''} 9	6 ^{''} 1		2	-8 ^{''} 2	5 ^{''} 1
	27	148 ^{''} 6	8 ^{''} 6		3	+67 ^{''} 4	4 ^{''} 6
	28	92 ^{''} 3	10 ^{''} 3		4	135 ^{''} 5	3 ^{''} 6
	29	+28 ^{''} 7	11 ^{''} 1		5	186 ^{''} 8	2 ^{''} 3
Mar.	1	-37 ^{''} 5	11 ^{''} 1		6	215 ^{''} 5	+0 ^{''} 7
	2	101 ^{''} 0	10 ^{''} 4		7	+219 ^{''} 5	-0 ^{''} 8
	3	157 ^{''} 8	9 ^{''} 0		8	199 ^{''} 5	2 ^{''} 2
	4	204 ^{''} 4	7 ^{''} 0		9	160 ^{''} 8	3 ^{''} 3
	5	237 ^{''} 7	4 ^{''} 5		10	107 ^{''} 3	4 ^{''} 1
	6	255 ^{''} 0	-2 ^{''} 0		11	+45 ^{''} 1	4 ^{''} 5
	7	254 ^{''} 6	+0 ^{''} 6		12	-20 ^{''} 5	4 ^{''} 5
	8	235 ^{''} 5	3 ^{''} 1		13	84 ^{''} 6	4 ^{''} 2
	9	197 ^{''} 6	5 ^{''} 3		14	142 ^{''} 8	3 ^{''} 6
	10	-142 ^{''} 7	7 ^{''} 0		15	191 ^{''} 6	2 ^{''} 9
	11	-74 ^{''} 5	7 ^{''} 9		16	227 ^{''} 6	2 ^{''} 0
	12	+1 ^{''} 9	8 ^{''} 0		17	248 ^{''} 6	-1 ^{''} 0
	13	77 ^{''} 7	7 ^{''} 2		18	252 ^{''} 4	0 ^{''} 0
	14	144 ^{''} 3	5 ^{''} 6		19	238 ^{''} 0	+0 ^{''} 9
	15	192 ^{''} 6	3 ^{''} 4		20	205 ^{''} 1	1 ^{''} 7
	16	219 ^{''} 2	+0 ^{''} 8		21	155 ^{''} 1	2 ^{''} 3
	17	+220 ^{''} 2	-1 ^{''} 7		22	-91 ^{''} 0	+2 ^{''} 7

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	$x,$	$y,$
1892. Apr. 23	- 17 ^{''} 9	+ 2 ^{''} 7
24	+ 57 ^{''} 1	2 ^{''} 5
25	124 ^{''} 9	2 ^{''} 0
26	177 ^{''} 5	1 ^{''} 3
27	208 ^{''} 5	+ 0 ^{''} 5
28	215 ^{''} 4	- 0 ^{''} 3
29	+ 198 ^{''} 8	- 1 ^{''} 1

	$x,$	$y,$
Apr. 30	+ 162 ^{''} 5	- 1 ^{''} 7
May 1	112 ^{''} 1	2 ^{''} 1
2	+ 52 ^{''} 2	2 ^{''} 3
3	- 11 ^{''} 5	2 ^{''} 4
4	74 ^{''} 3	2 ^{''} 2
5	- 131 ^{''} 9	- 2 ^{''} 0

The adopted zero meridian will pass the middle of the illuminated disc of *Saturn* at the following Greenwich mean times :—

1892. Mar.	h m	h m
1	11 4 ^{''} 7	21 19 ^{''} 0
2	7 33 ^{''} 3	17 47 ^{''} 6
3	4 1 ^{''} 9	14 16 ^{''} 2
4	10 44 ^{''} 8	20 59 ^{''} 1
5	7 13 ^{''} 4	17 27 ^{''} 7
6	3 42 ^{''} 0	13 56 ^{''} 3
7	10 25 ^{''} 0	20 39 ^{''} 3
8	6 53 ^{''} 6	17 7 ^{''} 9
9	3 22 ^{''} 2	13 36 ^{''} 5
10	10 5 ^{''} 1	20 19 ^{''} 4
11	6 33 ^{''} 7	16 48 ^{''} 1
12	3 2 ^{''} 4	13 16 ^{''} 7
13	9 45 ^{''} 3	19 59 ^{''} 6
14	6 13 ^{''} 9	16 28 ^{''} 2
15	2 42 ^{''} 5	12 56 ^{''} 9
16	9 25 ^{''} 5	19 39 ^{''} 8
17	5 54 ^{''} 1	16 8 ^{''} 4
18	2 22 ^{''} 7	12 37 ^{''} 1
19	9 5 ^{''} 7	19 20 ^{''} 0
20	5 34 ^{''} 3	15 48 ^{''} 6
21	2 2 ^{''} 9	12 17 ^{''} 3
22	8 45 ^{''} 9	19 0 ^{''} 2
23	5 14 ^{''} 5	15 28 ^{''} 9
24	1 43 ^{''} 2	11 57 ^{''} 5
25	8 26 ^{''} 1	18 40 ^{''} 5
26	4 54 ^{''} 8	15 9 ^{''} 1
27	1 23 ^{''} 4	11 37 ^{''} 7
28	8 6 ^{''} 4	18 20 ^{''} 7

1892. Mar.	h m	h m
29	4 35 ^{''} 0	14 49 ^{''} 4
30	1 3 ^{''} 7	11 18 ^{''} 0
31	7 46 ^{''} 7	18 1 ^{''} 0
Apr. 1	4 15 ^{''} 3	14 29 ^{''} 7
2	0 44 ^{''} 0	10 58 ^{''} 3
3	7 27 ^{''} 0	17 41 ^{''} 3
4	3 55 ^{''} 7	14 10 ^{''} 0
5	0 24 ^{''} 3	10 38 ^{''} 7
6	7 7 ^{''} 3	17 21 ^{''} 7
7	3 36 ^{''} 0	13 50 ^{''} 3
8	10 19 ^{''} 0	20 33 ^{''} 4
9	6 47 ^{''} 7	17 2 ^{''} 0
10	3 16 ^{''} 4	13 30 ^{''} 7
11	9 59 ^{''} 4	20 13 ^{''} 7
12	6 28 ^{''} 1	16 42 ^{''} 4
13	2 56 ^{''} 8	13 11 ^{''} 1
14	9 39 ^{''} 8	19 54 ^{''} 2
15	6 8 ^{''} 5	16 22 ^{''} 8
16	2 37 ^{''} 2	12 51 ^{''} 5
17	9 20 ^{''} 2	19 34 ^{''} 6
18	5 49 ^{''} 0	16 3 ^{''} 3
19	2 17 ^{''} 7	12 32 ^{''} 0
20	9 0 ^{''} 7	19 15 ^{''} 1
21	5 29 ^{''} 4	15 43 ^{''} 8
22	1 58 ^{''} 1	12 12 ^{''} 5
23	8 41 ^{''} 2	18 55 ^{''} 6
24	5 9 ^{''} 9	15 24 ^{''} 3
25	1 38 ^{''} 7	11 53 ^{''} 0

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Mr. Marth, Ephemerides of

LII, 3,

1892.	h	m	h	m	1892.	h	m	h	m
Apr. 26	8	21.8	18	36.1	June 4	4	11.3	14	25.8
27	4	50.5	15	4.8	5	0	40.2	10	54.6
28	1	19.2	11	33.6	6	7	23.4	17	37.9
29	8	2.3	18	16.7	7	3	52.3	14	6.7
30	4	31.1	14	45.4	8	0	21.1	10	35.5
May 1	0	59.8	11	14.2	9	7	4.4	17	18.8
2	7	42.9	17	57.3	10	3	33.2	13	47.7
3	4	11.7	14	26.0	11	0	2.1	10	16.5
4	0	40.4	10	54.8	12	6	45.4	16	59.8
5	7	23.5	17	37.9	13	3	14.2	13	28.6
6	3	52.3	14	6.7	14	9	57.5	20	11.9
7	0	21.0	10	35.4	15	6	26.3	16	40.8
8	7	4.2	17	18.6	16	2	55.2	13	9.6
9	3	32.9	13	47.3	17	9	38.5	19	52.9
10	0	1.7	10	16.1	18	6	7.3	16	21.8
11	6	44.9	16	59.2	19	2	36.2	12	50.6
12	3	13.6	13	28.0	20	9	19.5	19	33.9
13	9	56.8	20	11.2	21	5	48.4	16	2.8
14	6	25.6	16	40.0	22	2	17.2	12	31.7
15	2	54.4	13	8.8	23	9	0.6	19	15.0
16	9	37.5	19	51.9	24	5	29.4	15	43.9
17	6	6.3	16	20.7	25	1	58.3	12	12.7
18	2	35.1	12	49.5	26	8	41.6	18	56.0
19	9	18.3	19	32.7	27	5	10.5	15	24.9
20	5	47.1	16	1.5	28	1	39.3	11	53.8
21	2	15.9	12	30.3	29	8	22.7	18	37.1
22	8	59.1	19	13.5	30	4	51.6	15	6.0
23	5	27.9	15	42.3	July 1	1	20.4	11	34.9
24	1	56.7	12	11.1	2	8	3.8	18	18.2
25	8	39.9	18	54.3	3	4	32.7	14	47.1
26	5	8.7	15	23.1	4	1	1.5	11	16.0
27	1	37.5	11	51.9	5	7	44.9	17	59.3
28	8	20.7	18	35.2	6	4	13.8	14	28.2
29	4	49.6	15	4.0	7	0	42.7	10	57.1
30	1	18.4	11	32.8	8	7	26.0	17	40.4
31	8	1.6	18	16.0	9	3	54.9	14	9.3
June 1	4	30.4	14	44.9	10	0	23.8	10	38.2
2	0	59.3	11	13.7	11	7	7.1	17	21.6
3	7	42.5	17	56.9	12	3	36.0	13	50.5

1892.	h	m	h	m	1892.	h	m	h	m
July 13	0	49	10	19	July 17	6	29	16	43
14	6	48	17	27	18	2	58	13	12
15	3	17	13	31	19	9	41	19	56
16	10	05	20	15	20	6	10	16	25

The favourable opportunities of the present apparition of *Saturn* ought to be assiduously employed for careful observations of all the phenomena which may contribute to our better knowledge of the planet's system. Though exact measurements of both the coordinates of the relative positions of the satellites must be left to observers provided with superior micrometrical apparatus, most valuable results, not only for the orbits of the satellites, but also for the determination of the true dimensions of the ball and ring, may be obtained from careful estimations of the times of the conjunctions of the satellites with the end-points of the equatorial diameter and of the ring and also with one another. Observations of the conjunctions with the ball, or of the passages across the tangents parallel to the polar axis (the positions noted $\alpha \beta \gamma \delta$ in the following list) are of greater importance than the doubtful estimations of ingress and egress at the transits and occultations, and it is to be hoped that many observers will take part. They will get no such favourable opportunities again before the year 1907.

G.M.T.		G.M.T.		G.M.T.	
1892.	h	1892.	h	1892.	h
Mar. 1	8.7 Rh. γ	Mar. 3	18.4 Te. ζ	Mar. 5	21.7 Di. β
	11.9 Mi. ζ		20.4 Mi. θ		22.1 En. η
	13.2 En. ζ		20.4 Te. β		22.6 Te. η
	17.0 Di. θ		20.8 En. ϵ	6	8.2 En. θ
	17.8 Mi. η		22.3 Titan α		10.8 Mi. η
	19.0 Di. Ecl. D.		23.3 Te. γ		14.3 Te. θ
	19.5 En. η	4	10.7 Di. θ		14.6 En. ϵ
	21.1 Te. ζ		12.7 Di. Ecl. D.		16.2 Te. Ecl. D.
	22.5 Di. α		13.2 En. η		16.2 Mi. θ
	23.1 Te. β		13.6 Mi. η		19.2 Te. α
	23.1 Mi. θ		16.1 Di. α		21.2 Te. ϵ
2	10.5 Mi. ζ		17.1 Te. θ		22.1 Mi. ϵ
	11.9 En. ϵ		18.3 Di. ϵ	7	6.4 Di. Ecl. D.
	16.4 Mi. η		18.9 Te. Ecl. D.		7.0 En. η
	19.8 Te. θ		19.0 Mi. θ		9.4 Mi. η
	21.6 Te. Ecl. D.		22.0 Te. α		9.8 Di. α
	21.8 Mi. θ	5	9.7 En. ϵ		12.0 Di. ϵ
	22.0 En. ζ		12.0 Rh. ζ		13.0 Te. ζ
3	7.3 Di. γ		12.2 Mi. η		14.8 Mi. θ
	8.1 Rh. Ecl. D.		14.6 Rh. β		15.0 Te. β
	9.1 Mi. ζ		15.7 Te. ζ		17.1 En. θ
	9.5 Di. η		15.8 En. ζ		17.9 Te. γ
	12.3 Rh. α		17.6 Mi. θ		18.2 Rh. θ
	12.6 Titan θ		17.7 Te. β		19.9 Te. η
	14.5 En. θ		18.4 Rh. γ		20.6 Rh. Ecl. D.
	14.8 Rh. ϵ		19.5 Di. ζ		20.8 Mi. ϵ
	15.0 Mi. η		20.6 Te. γ	8	8.1 Mi. η
	15.8 Titan Ecl. D.		21.0 Rh. γ		9.5 En. ζ

G.M.T.		G.M.T.		G.M.T.	
1892.	h	1892.	h	1892.	h
Mar. 8	11:6 Te. θ	Mar. 12	15:6 Di. θ	Mar. 19	14:0 Di. β
	13:1 Di. ζ		17:8 Di. Ecl. D.		14:0 Titan δ
	13:5 Mi. θ		18:5 En. η		14:9 En. η
	13:6 Te. Ecl. D.		19:2 Mi. ζ		15:4 Mi. η
	15:3 Di. β		21:1 Di. α		17:2 Di. γ
	15:9 En. η	13	9:8 Te. γ		19:4 Te. θ
	16:5 Te. α		10:9 En. ϵ		19:4 Di. η
	18:5 Te. ϵ		11:8 Te. η		19:9 Titan α
	18:6 Di. γ	14	8:1 Di. η		20:8 Mi. θ
	19:4 Mi. ϵ		8:4 Te. α		21:4 Te. δ
	20:8 Di. η		10:4 Te. ϵ		23:7 Titan ϵ
9	8:3 En. ϵ		11:0 Mi. ϵ	20	7:3 En. ϵ
	10:3 Te. ζ		12:7 Rh. ζ		8:1 Mi. ζ
	12:1 Mi. θ		13:5 En. θ		14:0 Mi. η
	12:3 Te. β		15:2 Rh. β		17:4 En. ζ
	15:2 Te. γ		16:4 Mi. ζ		18:0 Te. ζ
	17:2 Te. η		19:1 Rh. γ		19:4 Mi. θ
	18:0 Mi. ϵ		19:8 En. ϵ		20:0 Te. β
	18:4 En. ζ		21:6 Rh. η		20:6 Di. θ
	22:0 Di. θ	15	7:1 Te. γ		22:8 Di. δ
10	6:8 Rh. γ		9:1 Te. η		22:9 Te. γ
	8:9 Te. θ		9:3 Di. θ	21	7:1 Rh. θ
	9:3 Rh. η		9:7 Mi. ϵ		9:7 Rh. δ
	10:7 Mi. θ		12:3 En. η		9:9 En. θ
	10:8 En. θ		14:7 Di. α		12:7 Mi. η
	10:9 Te. Ecl. D.		15:1 Mi. ζ		13:5 Rh. Ecl. R.
	13:8 Te. α		17:0 Di. ϵ		13:6 Rh. α
	15:8 Te. ϵ		21:0 Mi. η		16:1 Rh. ϵ
	16:6 Mi. ϵ	16	7:7 Te. ϵ		16:2 En. ϵ
	17:2 En. ϵ		8:3 Mi. ϵ		16:7 Te. θ
11	6:8 Di. ζ		13:7 Mi. ζ		18:1 Mi. θ
	7:6 Te. ζ		14:8 En. ζ		18:7 Te. δ
	8:3 Titan β		18:1 Di. ζ		21:6 Te. Ecl. R.
	9:0 Di. β		18:8 Rh. θ	22	7:6 Di. β
	9:3 Mi. θ		19:6 Mi. η		8:6 En. η
	9:6 Te. β		20:3 Di. β		10:9 Di. γ
	9:6 En. η		21:1 En. η		11:3 Mi. η
	10:6 Titan Sh.		21:4 Rh. δ		13:1 Di. η
	12:3 Di. γ	17	6:4 Te. η		15:3 Te. ζ
	12:5 Te. γ		6:9 Mi. ϵ		16:7 Mi. θ
	14:2 Titan γ		7:2 En. θ		17:3 Te. β
	14:5 Di. η		12:3 Mi. ζ		18:7 En. θ
	14:5 Te. η		13:6 En. ϵ		20:2 Te. γ
	15:2 Mi. ϵ		18:2 Mi. η	23	9:9 Mi. η
	18:0 Titan η		22:1 Te. θ		11:2 En. ζ
	19:7 En. θ	18	8:3 Di. Ecl. R.		13:3 Rh. ζ
	20:6 Mi. ζ		8:4 Di. α		14:0 Te. θ
12	6:2 Te. θ		10:6 Di. ϵ		14:2 Di. θ
	6:5 Rh. θ		10:9 Mi. ζ		15:3 Mi. θ
	7:9 Mi. θ		16:1 En. θ		15:9 Rh. β
	8:2 Te. Ecl. D.		16:8 Mi. η		16:0 Te. δ
	9:0 Rh. Ecl. D.		20:7 Te. ζ		16:4 Di. δ
	11:1 Te. α	19	7:4 Rh. γ		17:5 En. η
	12:2 En. ζ		8:5 En. ζ		18:9 Te. Ecl. R.
	12:9 Rh. α		9:5 Mi. ζ		19:7 Rh. γ
	13:1 Te. ϵ		10:0 Rh. η		19:7 Di. Ecl. R.
	13:8 Mi. ϵ		10:1 Titan θ		20:9 Te. ϵ
	15:5 Rh. ϵ		11:7 Di. ζ		21:2 Mi. ϵ

G.M.T.		G.M.T.		G.M.T.	
1892.	h	1892.	h	1892.	h
Mar. 23	21'9 Di. ϵ	Mar. 28	12'1 Te. γ	Apr. 3	15'0 Di. δ
	22'3 Rh. η		12'6 En. ϵ		16'5 En. η
24	8'5 Mi. η		14'1 Te. η		17'2 Mi. η
	10'0 En. ϵ		14'2 Mi. ϵ		18'5 Di. Ecl. R.
	12'6 Te. ζ		19'6 Mi. ζ		20'1 Rh. θ
	13'9 Mi. θ	29	7'1 Di. Ecl. R.		20'5 Di. ϵ
	14'6 Te. β		7'8 Te. δ		21'7 Te. θ
	17'5 Te. γ		9'2 Di. ϵ	4	7'7 Titan θ
	19'5 Te. η		10'8 Te. Ecl. R.		9'0 En. ϵ
	19'8 Mi. ϵ		12'7 Te. ϵ		9'9 Mi. ζ
	20'1 En. ζ		12'9 Mi. ϵ		11'6 Titan δ
25	6'7 Di. η		15'1 En. θ		15'9 Mi. η
	7'1 Mi. η		18'3 Mi. ζ		(17'5 Titan α)
	11'3 Te. θ		21'5 En. ϵ		17'6 Titan Ecl. R.
	12'5 En. θ	30	6'5 Te. β		19'1 En. ζ
	12'5 Mi. θ		7'6 En. ζ		20'4 Te. ζ
	13'3 Te. δ		7'8 Rh. θ		21'3 Mi. θ
	16'2 Te. Ecl. R.		9'4 Te. γ		21'4 Titan ϵ
	18'2 Te. ϵ		10'4 Di. ζ		21'7 Di. ζ
	18'4 Mi. ϵ		10'4 Rh. δ	5	8'6 Mi. ζ
	18'8 En. ϵ		11'4 Te. η		11'5 En. θ
	19'5 Rh. θ		11'5 Mi. ϵ		14'5 Mi. η
	22'0 Rh. δ		12'6 Di. β		17'9 En. ϵ
26	7'9 Di. θ		13'9 En. η		19'0 Te. θ
	9'9 Te. ζ		14'4 Rh. Ecl. R.		19'9 Mi. θ
	10'1 Di. δ		15'8 Di. γ		21'0 Te. δ
	10'1 Mi. θ		16'8 Rh. ϵ	6	8'7 Di. δ
	11'3 En. η		17'9 Mi. ζ		8'7 Rh. γ
	11'9 Te. β		18'0 Di. η		10'3 En. η
	13'4 Di. Ecl. R.	31	8'2 Te. Ecl. R.		11'3 Rh. η
	14'8 Te. η		10'0 Te. ϵ		12'2 Di. Ecl. R.
	15'6 Di. ϵ		10'1 Mi. ϵ		13'1 Mi. η
	16'8 Te. η		15'5 Mi. ζ		14'2 Di. ϵ
	17'0 Mi. ϵ		16'4 En. ζ		17'7 Te. ζ
	21'4 En. θ		19'2 Di. θ		18'5 Mi. θ
	22'4 Mi. ζ		21'4 Di. δ		19'7 Te. β
27	2'0 Titan ζ		21'4 Mi. η	7	11'7 Mi. η
	5'9 Titan β	Apr. 1	8'7 Te. η		12'8 En. ζ
	8'5 Te. θ		8'7 Mi. ϵ		15'3 Di. ζ
	9'7 Mi. θ		8'9 En. θ		16'3 Te. θ
	9'8 Titan Sh.		14'0 Rh. ζ		17'1 Mi. θ
	10'5 Te. δ		14'1 Mi. ζ		17'5 Di. β
	11'7 Titan γ		15'2 En. ϵ		18'3 Te. δ
	13'5 Te. Ecl. R.		16'5 Rh. β		19'2 En. η
	13'8 En. ζ		20'0 Mi. η		20'8 Di. γ
	15'5 Te. ϵ		20'4 Rh. γ		21'4 Te. Ecl. R.
	15'5 Titan η	2	6'2 Di. β	8	8'5 Rh. θ
	15'6 Mi. ϵ		7'3 Mi. ϵ		10'3 Mi. η
	16'7 Di. ζ		7'3 Te. ϵ		11'0 Rh. δ
	18'9 Di. β		7'7 En. η		11'6 En. ϵ
	20'1 En. η		9'5 Di. γ		15'0 Te. ζ
	21'0 Mi. ζ		11'7 Di. η		15'4 Rh. Ecl. R.
	22'2 Di. γ		12'7 Mi. ζ		15'7 Mi. θ
28	7'2 Te. ζ		17'8 En. θ		17'0 Te. β
	8'1 Rh. γ		18'6 Mi. η		17'5 Rh. ϵ
	8'3 Mi. θ	3	10'2 En. ζ		19'9 Te. γ
	9'2 Te. β		11'3 Mi. ζ	9	7'8 Di. ϵ
	10'6 Rh. η		12'8 Di. θ		8'9 Mi. η

G.M.T.		G.M.T.		G.M.T.	
1892.	h	1892.	h	1892.	h
Apr. 9	13 ⁶ Te. θ	Apr. 14	13 ³ Mi. ϵ	Apr. 20	19 ⁵ En. ϵ
	14 ² En. θ		13 ⁷ Di. δ	21	7 ⁶ Di. ζ
	14 ³ Mi. θ		13 ⁷ Te. η		9 ⁰ Mi. ζ
	15 ⁶ Te. δ		15 ⁶ En. η		9 ⁸ Di. β
	18 ⁷ Te. Ecl. R.		17 ³ Di. Ecl. R.		12 ⁰ En. η
	20 ² Mi. ϵ		18 ⁷ Mi. ζ		13 ¹ Di. γ
	20 ⁵ En. ϵ		19 ² Di. ϵ		14 ⁹ Mi. η
	20 ⁵ Te. ϵ	15	9 ⁴ Rh. γ		15 ³ Di. η
10	9 ⁰ Di. ζ		10 ⁷ Te. Ecl. R.		20 ⁰ Te. ζ
	11 ² Di. β		11 ⁹ Mi. ϵ	22	13 ⁵ Mi. η
	12 ² Te. ζ		12 ⁰ Rh. η		14 ⁵ En. ζ
	12 ⁹ En. η		12 ⁴ Te. ϵ		16 ⁵ Di. θ
	12 ⁹ Mi. θ		17 ³ Mi. ζ		18 ⁷ Di. δ
	14 ² Te. β		18 ¹ En. ζ		18 ⁷ Te. θ
	14 ⁵ Di. γ		20 ³ Di. ζ	23	12 ² Mi. η
	14 ⁶ Rh. ζ	16	9 ⁰ Te. γ		13 ³ En. ϵ
	16 ⁷ Di. η		10 ⁶ En. θ		17 ³ Te. ζ
	17 ² Te. γ		10 ⁶ Mi. ϵ		17 ⁶ Mi. θ
	17 ² Rh. β		11 ⁰ Te. η		19 ³ Te. β
	18 ⁹ Mi. ϵ		16 ⁰ Mi. ζ	24	9 ⁰ Di. η
	19 ² Te. η		16 ⁹ En. ϵ		10 ¹ Rh. γ
	21 ¹ Rh. γ	17	7 ³ Di. δ		10 ⁸ Mi. η
11	10 ⁹ Te. θ		8 ⁰ Te. Ecl. R.		12 ⁷ Rh. η
	11 ⁶ Mi. θ		9 ² Mi. ϵ		15 ⁸ En. θ
	12 ⁹ Te. δ		9 ² Rh. θ		16 ⁰ Te. θ
	15 ⁵ En. ζ		9 ³ En. η		16 ² Mi. θ
	16 ⁰ Te. Ecl. R.		9 ⁷ Te. ϵ		18 ⁰ Te. δ
	17 ⁵ Mi. ϵ		11 ⁰ Di. Ecl. R.	25	10 ¹ Di. θ
	17 ⁸ Di. θ		11 ⁷ Rh. δ		12 ³ Di. δ
	17 ⁸ Te. ϵ		12 ⁸ Di. ϵ		14 ⁶ En. η
	20 ⁰ Di. δ		14 ⁶ Mi. ζ		14 ⁶ Te. ζ
	23 ⁷ Titan ζ		16 ³ Rh. Ecl. R.		14 ⁸ Mi. θ
12	3 ⁵ Titan β		18 ² Rh. ϵ		16 ² Di. Ecl. R.
	7 ⁹ En. θ	18	8 ³ Te. η		16 ⁶ Te. β
	9 ⁰ Titan Sh.		11 ⁹ En. ζ		17 ⁸ Di. ϵ
	9 ³ Titan γ		13 ² Mi. ζ		19 ⁵ Te. γ
	9 ⁵ Te. ζ		14 ⁰ Di. ζ	26	9 ⁹ Rh. θ
	10 ² Mi. θ		16 ² Di. β		12 ⁵ Rh. δ
	11 ⁵ Te. β		18 ² En. η		13 ³ Te. θ
	13 ² Titan η		19 ¹ Mi. η		13 ⁴ Mi. θ
	14 ³ En. ϵ		19 ⁴ Di. γ		15 ³ Te. δ
	14 ⁵ Te. γ	19	10 ⁷ En. ϵ		17 ² En. ζ
	16 ¹ Mi. ϵ		11 ⁸ Mi. ζ		17 ² Rh. Ecl. R.
	16 ⁵ Te. η		15 ⁴ Rh. ζ		18 ⁶ Te. Ecl. R.
	20 ⁸ Rh. θ		17 ⁷ Mi. η		18 ⁹ Rh. ϵ
13	8 ¹ Di. γ		17 ⁹ Rh. β		19 ⁰ Di. ζ
	8 ² Te. θ		20 ⁸ En. ζ	27	11 ⁹ Te. ζ
	8 ⁸ Mi. θ		21 ⁸ Rh. γ		12 ⁰ Mi. θ
	10 ² Te. δ	20	9 ³ Titan δ		13 ⁹ Te. β
	10 ³ Di. η		10 ⁴ Mi. ζ		15 ⁹ En. ϵ
	13 ⁴ Te. Ecl. R.		13 ² En. θ		16 ⁸ Te. γ
	14 ⁷ Mi. ϵ		15 ² Titan α	28	7 ² Titan γ
	15 ¹ Te. ϵ		15 ⁶ Titan middle		8 ² axis of Ti-
	16 ⁸ En. θ		of Ecl. of		tan's shadow-
14	8 ⁸ Te. β		uncertain		cone just out-
	9 ² En. ζ		duration.		side the ball.
	11 ⁵ Di. θ		16 ³ Mi. η		8 ⁴ En. η
	11 ⁷ Te. γ		19 ⁰ Titan ϵ		

G.M.T.		G.M.T.		G.M.T.	
1892.	h	1892.	h	1892.	h
Apr. 28	9.9	Di. Ecl. R.	Apr. 28	17.5	Te. ϵ
	10.6	Te. θ	29	9.2	Te. ζ
	10.6	Mi. θ		9.3	Mi. θ
	11.1	Titan η		10.9	En. ζ
	11.5	Di. ϵ		11.2	Te. β
	12.6	Te. δ		12.6	Di. ζ
	15.9	Te. Ecl. R.		14.1	Te. γ
	16.1	Rh. ζ		14.8	Di. β
	16.6	Mi. ϵ		15.2	Mi. ϵ

(To be concluded.)

Ephemeris of the Satellites of Uranus, 1892. By A. Marth.

Greenwich Noon, 1892.	Ariel.					Umbriel.				
	P	a_1	b_1	$u_1 - U$	Diff.	a_2	b_2	$u_2 - U$	Diff.	
Mar. I	277° 70	14° 75	+ 11° 14	185° 25	1428° 39	20° 55	+ 15° 52	267° 40	868° 68	
II	277° 81	14° 86	11° 19	173° 64	.35	20° 70	15° 58	56° 08	.65	
2I	277° 94	14° 95	11° 21	161° 99	.32	20° 83	15° 61	204° 73	.62	
3I	278° 09	15° 02	11° 20	150° 31	.28	20° 93	15° 60	350° 35	.60	
Apr. 10	278° 26	15° 07	11° 17	138° 59	.26	20° 99	15° 56	141° 95	.58	
20	278° 44	15° 09	11° 11	126° 85	.23	21° 02	15° 48	290° 53	.57	
30	278° 62	15° 09	+ 11° 03	115° 08	.21	21° 02	+ 15° 37	79° 10	.56	
May 10	278° 78	15° 06	10° 94	103° 29	.20	20° 98	15° 24	227° 66	.55	
20	278° 93	15° 01	10° 83	91° 49	.20	20° 90	15° 09	16° 21	.56	
30	279° 06	14° 93	10° 72	79° 69	.19	20° 80	14° 93	164° 77	.56	
June 9	279° 17	14° 83	10° 60	67° 88	.20	20° 67	14° 77	313° 33	.57	
19	279° 25	14° 73	10° 49	56° 08	1428° 20	20° 52	14° 61	101° 90	868° 59	
29	279° 29	14° 61	+ 10° 38	44° 28		20° 35	+ 14° 46	250° 49		
	Titania.				Oberon.					
	a_3	b_3	$u_3 - U$	Diff.	a_4	b_4	$u_4 - U$	U	B	
Mar. I	33° 71	+ 25° 46	253° 37	413° 47	45° 07	+ 34° 05	191° 93	357° 105	+ 49° 06	
II	33° 95	25° 56	306° 84	.45	45° 40	34° 18	99° 27	.178	48° 85	
2I	34° 16	25° 61	0° 29	.42	45° 68	34° 24	6° 59	.270	48° 56	
3I	34° 32	25° 59	53° 71	.41	45° 90	34° 22	273° 89	.377	48° 21	
Apr. 10	34° 43	25° 52	107° 12	.40	46° 04	34° 12	181° 18	.494	47° 82	
20	34° 48	25° 39	160° 52	.39	46° 11	33° 95	88° 46	.615	47° 41	
30	34° 47	+ 25° 21	213° 91	.39	46° 10	+ 33° 72	355° 73	.735	+ 47° 00	
May 10	34° 41	25° 00	267° 30	.40	46° 01	33° 43	263° 00	.848	46° 59	
20	34° 29	24° 75	320° 70	.40	45° 85	33° 10	170° 28	357° 950	46° 21	
30	34° 12	24° 49	14° 10	.42	45° 62	32° 75	77° 58	358° 037	45° 88	
June 9	33° 90	24° 22	67° 52	.43	45° 34	32° 40	344° 88	358° 107	45° 60	
19	33° 65	23° 96	120° 95	413° 45	45° 01	32° 05	252° 20	358° 157	45° 39	
29	33° 38	+ 23° 71	174° 40		44° 64	+ 31° 71	159° 55	358° 183	+ 45° 27	

The values of P , a , b , $u - U$ being interpolated for the times for which the apparent positions of the satellites are required, the position-angles p and distances s of the satellites are found by means of the formulæ :

$$s \sin (p - P) = a \sin (u - U) ;$$

$$s \cos (p - P) = b \cos (u - U).$$

It is very desirable that some good positions of the satellites should be procured ; the inner ones especially have been already too long neglected.

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Erratum in "Monthly Notices."

Vol. li., Appendix vii., pp. 176, 177, for Professor E. S. Holden, read The Lick Observatory.